*Reporting Southern Trip of American Electrochemical Society*

# Metallurgical & Chemical Engineering

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# Metallurgical and Chemical Engineering

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### Keep Our Young Men in College

OUR country is confronted with a serious menace to her future welfare through the patriotic response of her young college men to the call for military service. When the war began in 1914 there was a large volunteer movement among students from France and England, to such an extent, indeed, that England later found it necessary to recall from France her technically trained young men. France shortly discovered that her own schools were being deserted, and saw the necessity of recruiting students to furnish a supply of engineers and technologists for the future. With this experience before us, our educators were prepared to sound the necessary warning when the United States entered the war, and almost from the beginning of our participation we have made special efforts to keep young men in college, particularly those who were studying scientific and engineering courses.

More recent data on the situation have been made public through an article by Huber William Hurt in a recent issue of *School and Society*, wherein it is shown that thirty educational institutions in the United States have 26,000 fewer students than they had last school year. The total loss for the higher institutions of learning is estimated at 68,500, which is the number of vacancies that ought to be filled if our colleges and universities are to render full service to the country.

We conceive it to be the duty of engineers everywhere to take definite steps to see that young men now in college are shown the necessity of pursuing their work to the end, and that young men eligible for college training are urged and even assisted to attend a nearby college. There are dozens of ways for a young man to get through college if the spirit wills, and assistance may range from showing how the trick may be turned, to actual financial support during the period of instruction. Here is an opportunity for real service which engineers should not neglect.

### Something Usually Lacking in Annual Reports

IT IS said that when the late Abram S. Hewitt was invited to join the board of the United States Steel Corporation at the time it was organized, he refused to do so unless the directors agreed to take the public into their confidence and tell in cold print everything that was done. He insisted that details be given which theretofore were held impossible to disclose, lest competitors learn too much. The argument lasted until late at night, the old ex-mayor holding that the concern was big enough to stand it; that the temper of the times demanded that all the facts be told; that whatever the corporation did that was right it could be proud of and

that whatever it did that was wrong would be found out anyway. He carried his point and to this day men of good-will have not regretted it. The Steel Corporation was one of the pioneers in telling stockholders and the public the things they should know but did not expect to learn. Things both favorable and unfavorable are told with splendid frankness.

The peculiarity—and we might almost say the trouble—with doing one good thing is that it is expected to lead to another, and then to another, and so on without ceasing. It is a feature of the *mores*, of the folkways, of public opinion, that if we blaze a trail of merit of any sort we are expected not only to continue in the path of righteousness, but to take the lead in other respects—all for the public good. One of the first things we learn in childhood is that obedience to parental discipline does not grant exemptions, even though other children persevere in naughtiness.

Now that publicity in the administration of affairs, and about bulk and tonnages, and things not done and things done, and building operations, and costs as well as profits, has been made in their annual reports, we conform to custom and cry for more. We want to see publicity in regard to the administration of materials and to learn about the progress of research from year tc year. We are aware that the subject is delicate, that it would be indiscreet to reveal the things hoped for or that are of promise in laboratories or that have reached a semi-commercial scale. It would not be expedient to tell of strategems in manufacture for competitors to imitate. Dividends are, after all, the basis of industry and they must not be neglected. But this is just what we are coming around to: One of the most important features desired of dividends is that they bid fair to continue, and the best way to provide for future dividends is to keep ahead of the game, while the way to keep ahead of the game is by research.

Dr. Mees said the other night at a meeting of the Society of Chemical Industry at the Chemists' Club, that he had found both in England and America about the same cost for building and maintaining research laboratories before the war. He said that $3500 per man to be employed was approximately the cost to build and equip an industrial research laboratory designed for one establishment in one industry, and that the annual maintenance expenses were about the same. Thus if a corporation that had such a laboratory established were to state in its annual report that $35,000 had been expended from its research fund, it would have been fair guessing up to 1915 that there had been about the value of ten men engaged in this kind of work. Of course, it would only be guessing, and it would give no intimation of the merits or the results of the effort. We offer it merely as an alleged measuring stick with no guarantees whatever, beyond the intimation that Dr. Mees has done excellent work in the Eastman laboratory at Rochester, and that he speaks with large experience.

We have no desire to demand of corporations details of their business which it would be unwise to publish. We merely point out that all information on the subject of research is usually suppressed, which we think a mistake. We know, for instance, that the Steel Corporation is diligent in this respect, which reassures us as stockholders; but we learn nothing of it in their annual report.

It is surprising how rapidly the public mind changes. A few years ago the mere mention of a chemical expression was regarded as impolite because nobody reasonable was supposed to know what it meant—and chemistry was held to be made in Germany anyway! Now the question is constantly asked whether we are scientific enough to compete with European countries after the war. The anxiety is less serious in regard to the steel and certain non-ferrous metal industries than it is concerning those which are regarded as more specifically chemical; but it is well to remember that even in variety of special steels the Germans were eminent before the war.

Slowly the fact is dawning upon the public consciousness that in nearly every great industry somebody is working away all the time to find improvement or economy or variety, either in this country or somewhere else. Wherever sound research is carried on the chances are much greater that improvements will be discovered and developed. In one sense, research is going hunting; in another it may be regarded as a modified form of insurance towards future benefit, and it is fair to say that manufacturing organizations that do not engage in it, lack this insurance. They not only lack this insurance but they lack something else; for wherever research is carried on intelligently and with understanding and with a wholesome belief in it, the entire organization becomes alive with the consciousness that improvements are sought. It sharpens the eyes of the whole force and it drives away the monotony of work. Therefore we think it a good thing to tell something in annual reports of the attitude of the administration of great industrial establishments toward this subject; to give at least the encouraging information, if the facts bear it out, that research is in progress.

Of course the rule-of-thumb people are always anxious to prove that they are scientific, science having come into fashion of late. If anything is said of research by the real leaders who engage in it, the rule-of-thumb people will follow the lead and, as likely as not, issue what is sometimes called "blurbs" on their control laboratories in the hope that a credulous public will believe them to be maintaining institutes of research. This will not mislead the technical press. The very ignorance of technical matters within boards of directors about which we have frequently complained is likely to show itself in this respect. But if those who engage in genuine research can be induced to tell something of the measure of their activities in this great field, it may give the less progressive concerns enough of a jolt to make them see a light—which would be a great benefit to American industry.

### Iron and Steel Production Rates

IN January and February pig iron was produced in the United States at an average rate below 30,000,000 tons a year. Since April 1 the rate has averaged well above 40,000,000 tons. A favorite estimate of blast-furnace capacity now existing is 43,000,000 tons, and it is quite possible that pig iron will be produced at such a rate in the near future. The controlling factor has been coke. Estimates of the steel ingot capacity range from 47,000,000 to 50,000,000 tons, but from the pres-

ent alignment it seems improbable that if pig iron production reaches a rate of 43,000,000 tons ingot production will reach a rate of 47,000,000 tons.

These and related facts embody two problems: (1) There was something radically wrong with coke production, movement and utilization last winter, and a recurrence of the conditions next winter must be avoided. (2) There is room for further ingenuity on the part of steel works managers in making bricks without straw, or in other words open-hearth steel with a scrap supply quite below normal.

It may prove to have been a very costly oversight if the experience of last winter's curtailment in pig iron production is remembered merely as a shortage of transportation for coke. That has been the common view, but there was a great deal more in the matter than that. The amount of pig iron that was produced, in January and February, from the coke that was available, was far below what would have been produced from that amount of coke under normal working conditions, and as conditions have been partly righted there has been a greater increase in the production of pig iron than in the production of coke.

There were three factors producing an inefficient utilization of the facilities that were available. In the first place, the beehive ovens in many cases did not produce good coke because, awaiting cars, coke was frequently held in the oven too long. In the case of the Connellsville region at least the coke operator was not free to blow out ovens, when car supplies averaged less than necessary to take care of full production by the ovens in blast, because he did not wish to commit business suicide. The absurd system of car distribution in the Connellsville region allots cars, when there is an insufficient supply on the railroad division, in proportion to the number of ovens in blast at each plant. If the operator blows out some ovens this week, his allotment is cut down next week. It is not instantaneous suicide, but the process would be sure. The result of the absurd system of the railroads is poor coke, overburned, and high coke consumption per ton of pig iron produced. In the second place, through irregularities in the receipt of coke, many blast furnaces had to bank at intervals. At such times the coke consumption per ton of pig iron produced is the invariable result when a finite quantity is divided by zero, the symbol being $\infty$. In the third place, many blast furnaces had to run at gaited rates for long periods. The detached furnace, or pair of furnaces, had no alternative but to make the best of things. A valley furnace manager made what was considered a remarkable record, running at about 50 per cent for several weeks, with an increase of only 10 per cent in coke consumption, but that would be an 11 per cent loss in pig iron over what would have been produced in the industry as a whole if the furnaces operated thus, instead of enough being blown out to give a full coke supply to the remainder.

A compilation showing the coke consumption per ton of pig iron at all blast furnaces last January and February, compared with normal performance at the same furnaces is needed, not to prove that there was much waste of coke last winter, plus much production of poor coke, for the general facts are known, but to emphasize how serious the loss was. If anyone has doubt that there was a very serious loss, let him reflect that conditions as to quality of coke and quantity and regularity of supply were much less objectionable in the year 1917 as a whole than they were last winter. Then let him seek an explanation of the statistical fact that from 1916 to 1917 there was an increase of 2,000,000 tons in the production of coke (Geological Survey) and a decrease of 800,000 tons in the production of pig iron (American Iron and Steel Institute).

No such experience must occur next winter. It is to be hoped that there will be ample transportation facilities, but if there are not, the cars available must be furnished in such manner as to conduce to as regular operation of beehive ovens as possible, and the production of the best coke that can be made. If there is not going to be enough coke at blast furnaces, then the coke must be so employed as to produce the maximum tonnage of pig iron possible with it.

The other problem, referring to the present and not next winter, is to bring about a better balance between pig iron production and steel ingot prodction. In proportion to rated capacities the production of steel ingots has been less than the production of pig iron, and that is a remarkable condition seeing that the iron foundries are not consuming their normal proportion of the total make of pig iron. The condition is due to one or both of two things—too much steel making capacity in proportion to blast furnace capacity, or not enough scrap. As long as pig iron does not accumulate, the individual works manager may be doing his best. He may have a full supply of pig iron, use it all, and get from his open-hearth furnaces only 85 per cent of their rated capacity. With more scrap he might produce ingots at 100 per cent.

The problem of regulating or controlling the scrap movement has been a very difficult one, in comparison with which the setting of prices on plates, or pig iron or even coke, has been extremely simple. It was necessary that scrap prices be limited, but when that was done very little scrap proved available. The dealers insisted that they should be permitted to charge a commission to consumers for handling scrap for them. After much discussion the commission was allowed, April 30, by the War Industries Board. Since then the offerings of scrap have not materially improved. The dealers have not made good on their representations that allowance of the commission would produce scrap, and the showing is particularly in point, because during the pendency of the discussion as to whether or not a commission would be allowed, holders of scrap would naturally keep it, while on the allowance of the commission they would hasten to sell. If there is scrap in the country the scrap should be found, commandeered by the authorities and put at the disposal of open-hearth furnaces.

If on the other hand there is not going to be a normal supply of scrap, the balance fitting the situation should be produced. If there is not enough blast-furnace capacity in proportion to steel-making capacity, the necessary steps should be taken, under authority of the Government, to hasten completion of blast furnaces now in course of erection, or to build new furnaces. There have been some remarkable records of blast-furnace building, when the builders had merely brains and money. Now the work could be hastened by government authority.

# Southern Convention of the American Electrochemical Society

**Tour of Southern Industrial Centers, Including the New Nitrate Plants at Muscle Shoals and New Power Developments in Tennessee and Alabama—Report of Technical and Business Sessions—F. J. Tone of Niagara Falls Elected President**

THAT a war-time convention of scientists and engineers can be held with resultant benefit to the participants, the region visited and the nation at large was amply demonstrated by the American Electrochemical Society in its tour of the Appalachian South during the entire week of April 28. The serious purpose behind the convention and the prospective benefit to the country may be inferred from the action of Director General McAdoo in approving the use of a special train to transport the Society from Washington as far south as Birmingham and return.

AMERICAN ELECTROCHEMICAL SOCIETY AT

North and South were brought together in a way that could not have been accomplished otherwise, and those who had been strangers to the potentialities of the South realized the possibility of so developing the raw material and power resources of the region as to establish an extensive chemical and electrochemical industry in the course of the next few years. Certainly a good beginning has been made in the production of iron, steel, ferro alloys, fixed nitrogen, cement, wood pulp, coke and its by-products, sulphuric acid, dyes and explosives.

The establishment of two great nitrogen-fixation plants at Sheffield and Muscle Shoals, makes of northern Alabama one of our largest chemical and electrochemical centers. No one could visit these plants without experiencing a sense of pride in what has been accomplished up to date, and a feeling of gratitude toward those who have sacrificed personal interests for the nation's good by devoting their time, talents and professional experience to the vital matter of producing ammonium nitrate.

If the visitors from the North gained inspiration and knowledge from their trip, there is also abundant testimony from the Society's hosts that the meetings brought encouragement and professional gain to them. Notes were freely exchanged and the best of professional fellowship prevailed. That there was tangible gain to both host and guest was therefore inevitable. The nation's war program was uppermost in the minds of all, with the purpose to contribute in every possible way to its advancement.

### Assembly and Registration at Washington

As a pleasant prelude to the railway journey, the members and guests of the Society who had gathered at Washington on Sunday, April 28, were shown the courtesy of a private visit to the Executive Offices, Cabinet Room, etc., in the White House, through arrangements made with Secretary Tumulty by the Washington representative of METALLURGICAL & CHEMICAL ENGINEERING. The interest of the visitors centered not

only in the older historical events that had transpired in these rooms, but also in the vital national issues that are there decided from day to day at the present time. The war maps on the walls of the Cabinet Room, corrected daily to show the positions of the contending forces in Europe, were objects of special interest.

### Directors Meet En Route

Leaving Washington Sunday evening, the directors of the Society assembled in the observation car for a meeting at which were presented the annual reports of officers and committees. The Society was found to be in excellent condition financially, and a comprehensive campaign for membership was outlined.

On the following day, Monday, April 29, two points in Tennessee were visited, Johnson City and Kingsport.

## Johnson City, Tennessee

At this point known as the Gateway to the Appalachian South, the visitors were the breakfast guests of the local Chamber of Commerce. After an address of welcome by Lee F. Miller, president of Chamber, and response for the Society by President Fink, the visitors were taken about the city in automobiles. Time did not permit a visit to the chemical plant of the Clinchfield Products Co., manufacturers of barium products. It was also learned that this concern makes sodium sulphide for the production of dyes at the Federal Dye Stuff & Chemical Corporation at Kingsport, using as one of the raw materials nitre cake from the sulphuric acid works of the Tennessee Copper Co. at Copperhill.

## Kingsport, Tennessee

This community is one of the most interesting and promising chemical centers of the South. It has been developed largely through the intelligent efforts of the Industrial Department of the Carolina, Clinchfield & Ohio Ry., and is an excellent example of logical and systematic planning to produce an independent and coordinated industrial center. The variety of chemical and other industries operating here is indicated by a partial list of the products: Cement, wood pulp, tanning extract, clay products, dyes, explosives, leather, wood distillation products and potash from cement. Add to these such local mineral resources as barytes, bauxite, feldspar, manganese, limestone, marble, mica, salt, phosphate and pyrite, and one readily sees a wonderful opportunity for future development.

Arriving at Kingsport the Society assembled at the Inn where addresses were made by V. V. Kelsey, J. F. Johnson and Ex-Governor John I. Cox, who reviewed the early history of the region and explained its resources. At noon the party was taken to Rotherwood Farm where a complimentary luncheon was served. In the afternoon the members were given an opportunity to visit the plants of the following companies: Federal Dye Stuff & Chemical Co., Clinchfield Portland Cement Corp., Kingsport Brick Corp., Kingsport Extract Corp., American Wood Reduction Corp., Kingsport Pulp Corp., and Kingsport Tanning Corp. Particular interest centered in the chlorine, dye and explosives departments of the Federal Co., the continuous causticizing plant[1] of the Pulp Corp., and the Cottrell potash-recovery plant at the Cement Corp., the last being under construction.

HOTEL TUTWILER, BIRMINGHAM, ALA.

### Annual Business Meeting

In the evening a complimentary dinner was served at the Inn, followed by the annual business meeting and a dance at the Federal Club.

The annual report of the Directors showed among other items the investment of $2000 of the Society's funds in each of the three Liberty Loans. An amendment to the constitution providing for honorary members was adopted by a large majority. Officers elected

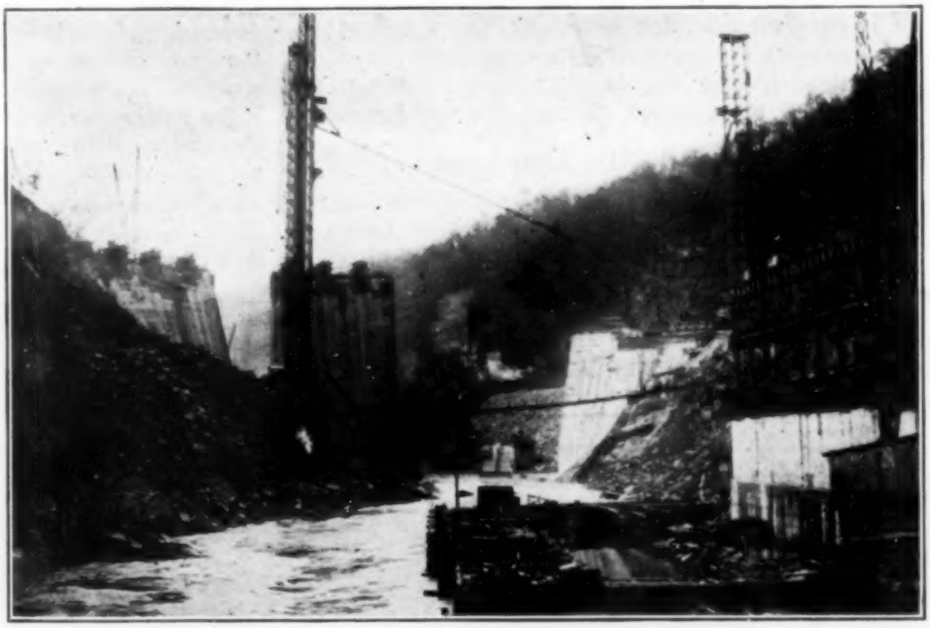
[1]See this journal April 1, 1918, p. 376.

for the ensuing year were announced as follows: President, F. J. Tone; Vice-presidents, Acheson Smith, H. W. Gillett and R. Turnbull; Managers, C. F. Burgess, E. L. Crosby and C. G. Schluederberg; Treasurer, P. G. Salom; Secretary, J. W. Richards.

## Knoxville District, Tennessee

Tuesday morning, April 30, the party had breakfast at Mascot as guests of the American Zinc Co., and later visited the company's zinc-ore concentration plant. An interesting feature of the flotation process at this plant is the preliminary treatment of the pulp with a solution of copper sulphate to aid in the flotation of the blende. The company's metallurgists have been conducting some interesting researches in preferential flotation, the results of which we expect to present in detail in the near future.

Arriving at Knoxville the party was taken immediately by special train as guests of the Board of Commerce and the Aluminum Company of America to see the hydro-electric developments of the latter on the Little Tennessee River. The complete project of this company contemplates the construction of a series of perhaps seven dams and power plants beginning at Alcoa and continuing at intervals up the river, each dam being located at the upper end of the lake created by the one next below. Work is now under way on No. 2 dam at Cheoah, as shown in the accompanying photographs. This dam is 200 ft. high and is reported to be the highest overfall dam in the world. During flood seasons water will flow 10 ft. deep over the crest. The power plant will develop 80,000 hp. The entire project is made possible through an agreement between the Aluminum Company and the Southern Railway providing for the relocation and construction of the latter's railroad.



DAM AND POWER HOUSE FOR ALUMINUM COMPANY OF AMERICA, AT CHEOAH ON THE LITTLE TENNESSEE RIVER

At noon the members of the party were guests of the Aluminum Co. at luncheon at Alcoa, the site of development No. 1.

### Technical Session at University of Tennessee

Returning to Knoxville the Society assembled at the University of Tennessee where a technical session was held following a brief address by President Brown Ayres.

### Hydro-Electric Power in Quebec and Ontario

A description of possible hydro-electric power development of the waters of the Ottawa River, near the city of Ottawa, and of the waters of the St. Lawrence River, near Montreal, was given by Louis Simpson, industrial engineer of Ottawa. He mentioned especially the Chats Falls, 32 miles west of Ottawa, where it is possible to develop between 110,000 and 120,000 e. hp. The possible head is 50 ft., and ice troubles can be reduced to a minimum. He also mentioned the possibility of constructing a canal from Lake St. Francis to a power house located on the Lake St. Louis, both these lakes being enlargements of the River St. Lawrence. The possible head will be 80 feet, and it will be possible to develop 1,000,000 hp. This development, also, if properly engineered, would be free from ice troubles.

In discussion of this subject Mr. C. A. Winder thought the author was too optimistic regarding freedom from ice troubles as featured in the paper, and also questioned the possibility of developing the amount of power on the Ottawa river as claimed by the author.

Mr. H. S. Randall, Jr., challenged the author's statement that there are but few undeveloped water powers of considerable magnitude, and cited Maine and Labrador as localities where large undeveloped powers still existed. In the latter country there are heads of over 200 ft. where there would be freedom from ice troubles.

### Storage Battery Capacities

C. W. Hazelett, storage battery engineer of the National Carbon Co., presented an interesting discussion of the calculation of storage batteries together with an alignment chart and circular slide rule for calculating these capacities. The use of one million storage batteries for automobile starting purposes imposes new conditions of service which former methods of determining capacities do not cover satisfactorily. It is important that final voltages be standardized as a continuous function of the time rate of discharge, in order that the condition of the cells at end of discharge at any time rate shall be approximately the same, and that all capacity data may be correlative. An equation for this final voltage is suggested and the work of Messrs. Spencer and Naiden was reviewed. They demonstrated that the capacity of the starting battery was a single, definite function of the time.

The conclusions from his work given by the author are as follows:

1. The systematization of storage battery testing demands that all data shall be based on time rates if they are in any way to be universal.

2. The capacity of any Faure or pasted-type starting battery cell between the time limits of 5 minutes and the 100-hour rates of discharge, and of all commercial-type vehicle plates between the 30-minute and 12-hour rates, is a definite single function of the time; *i. e.*, Log $I\ f\ (T)$ (Log $T$) $= K$, where $I$ is the current, $T$ the time, $K$ the capacity in ampere hours times some constant, and $(f)\ (T)$ a definite function of the time.

3. It is essential to have a universal final voltage equation which is scientific and a definite function of the time. The formula

$$E = 1.85 - \frac{0.448}{\text{Log } T}(T \text{ given minutes})$$

is offered as a scientific and practical equation.

4. The charging and finish-charging rates of any cell should be a definite time rate of discharge. The 7- and 18-hour rates are respectively recommended.

### Sign of the Live Electrode

A comprehensive discussion of this subject was given by Prof. W. D. BANCROFT, of Cornell University. Professor Bancroft said the German physical chemists have changed their position several times as to the sign to be applied to the zinc electrode. At present the Germans use the minus sign for the potential of zinc in zinc sulphate solution, as do also the English. In this country the practice is by no means uniform. Professor Bancroft summarized his discussion of the subject as follows:

1. The chemical potential of the zinc in the Daniell cell is greater than the chemical potential of the copper, but the electrical potential is less.

2. With electrodes which form cations the electromotive force is a measure of the difference of the chemical potentials, but has the opposite sign; with electrodes which form anions it has the same sign.

3. Since the electrical potential of the copper in the Daniell cell is higher than that of zinc, and since the zinc electrode is the place of lowest electrical potential, though highest chemical potential, we ought to use the minus sign when speaking of the electrical potential difference Zn | $ZnSO_4$.

4. Calling the zinc potential minus is in line with the practice of all physicists, of the Bunsen Society, and of the Faraday Society.

5. The distinction between chemical potential and electrical potential was stated concisely by Gibbs.

Discussing DR. BANCROFT'S paper, DR. HERING stated that it represented the views of the majority of a committee previously appointed to consider the matter. MESSRS. MOTT, HERING and BANCROFT favored the view just presented, while MR. WATTS thought that the use of the + sign for Na, Zn, etc., and the — sign for Cu, Pt, etc., would follow long established custom and avoid confusion. Dr. Hering stated that the difficulty was that those who originally guessed at the direction of the flow of the current had guessed wrong, with consequent misleading practice in the use of signs. DR. RICHARDS sympathized with the view of Mr. Watts on account of the phrasing of the author's conclusions, objecting to the statement that the electrical potential of Zn is less than that of Cu unless it is specified that it is algebraically and not numerically less.

### Resistivity of Porcelain and Magnesia

Tests of the electrical resistivity of calcined magnesite and porcelain were described by P. H. BRACE, research chemist of the Westinghouse Electric & Mfg. Co. The resistivity was measured from 430 to 990 deg. C. of (1) calcined magnesite (impure magnesia) completely fused in an arc furnace and free from cracks and blow holes, (2) molded calcined magnesite baked at 1700 deg. C., (3) porcelain such as is used for spark plug insulators, using direct current. The magnesia had greater resistivity than the porcelain at all temperatures investigated. Uni-lateral effects due to the direct current were noted, and the porcelain gave back electromotive forces up to 0.7 volt.

DR. E. C. SULLIVAN thought the author had neglected to emphasize an important point, viz., that the change in resistance with time was less at high temperatures than at low. President FINK commented on the author's failure to tell how he fired MgO pellets at 1700 deg., and wondered what atmosphere was used. A reducing atmosphere would convert FeO to Fe which would coat the MgO and destroy the resistivity. This would account in part for the better resistivity of molded than fused MgO. DR. NORTHROP thought that results of greater scientific value would be secured if work of this type were done on pure substances of simple composition rather than on complex materials. The results obtained on the latter are empirical and useful only for some practical end, whereas the other procedure would enable us to determine the reasons for the results obtained.

### Determination of Gases in Metals

A precision method for the determination of gases in metals was described by H. M. RYDER, research chemist for the Westinghouse Electric & Mfg. Co.

The metal to be investigated is mounted as a thin ribbon or filament in an electric-light bulb, which is then evacuated. The temperature of the filament is then raised by an electric current, and the pump being kept going the gases evolved are continually forced out into a collecting tube. The temperature is raised in steps of 50 deg. C. up to the melting point, and the gases evolved at each temperature measured and analyzed. The bulb is water-cooled, in order to prevent the glass giving off gases on becoming heated. One or two cubic millimeters of gas can be thus measured and analyzed. Silicon steel was found to give off gas abundantly at the $Ar_3$ point, 730 deg. C. The process of gas analysis is novel and interesting. The $CO_2$ and $H_2O$ vapor are first frozen out with liquid air, and the remaining "dry" gases are pumped into a small chamber by means of a modified Töpler pump. The $CO_2$ is then separated from the water vapor by substituting carbon dioxide snow for the liquid air. The quantity of $CO_2$ released is determined by measuring with a McLeod gauge the pressure due to it in a volume accurately known. It is then pumped out of the system and the water vapor released by removing the carbon dioxide snow. The pressure due

to this is determined by using a mercury U-tube manometer with an optical lever attachment[1].

Oxygen is added to the remaining gases, which have been returned to the main analysis system, and the CO, $H_2$, and $CH_4$ burned in a small combustion bulb, a hot platinum filament being used to start the reaction. The $CO_2$ and $H_2O$ vapor formed are measured as before and the quantity of CO, $H_2$, and $CH_4$ determined from this and a knowledge of the decrease in the quantity of the mixture of gases. CO added to the remaining gases and burned provides for the determination of the excess oxygen and any oxygen which might be originally present in the gases. Nitrogen is determined, technically, by difference, but the method permits of a check on its value.

### Arc Furnace for Nitrogen-Fixation

A paper on this general subject, not on the program, was presented by E. Kilbourn Scott. He explained briefly the essential differences between nitrogen furnaces and others, to wit: the electrodes are of metal instead of carbon, and the voltage is 5000 or more. One difficulty with all single-phase furnaces is that a great deal of the air entering the furnace does not get into the arc and is unaffected. The author sketched a design of his own furnace, three-phase, in which a maximum of air is reacted upon by the arcs. He described the development of nitrogen furnaces from those of 150 kw. 10 years ago to 4000 kw. now. Yields of nitric acid have now been obtained as high as 85 grams per kw.-hr. at a concentration of 1.3 to 1.5 per cent.

### Program at Banquet

On Wednesday evening the Cherokee Country Club was the scene of a banquet tendered the Society by the Knoxville Board of Commerce. Toastmaster Hugh M. Tate gave the proceedings a distinct patriotic tone and commented on the cosmopolitan character of the Society's membership as represented on the Southern tour.

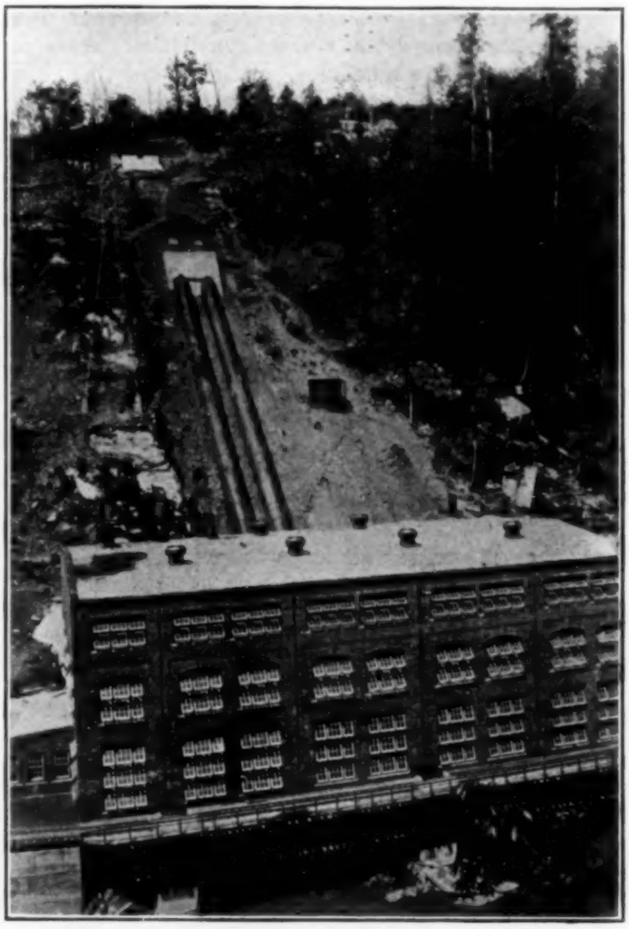
Three notable addresses were delivered following the banquet. The first was the annual address of President C. G. Fink, "Electrochemistry and National Economy." This will be published in full in a later issue.

The second was by John A. Switzer, professor of hydraulic engineering, University of Tennessee, who had during the preceding six weeks made a reconnaissance of undeveloped hydroelectric power sites in eastern Tennessee, capable of developing over 5000 hp. each. His surveys covered the Power, Clinch, Holston, French Broad, Hiwassee, Ocoee and Little Tennessee rivers. Stereopticon views were shown of the localities as well as of proposed dams and reservoirs. In all he described 21 sites at which could be developed a total of 750,000 hp. Prof. Switzer repeatedly explained in connection with several of the projects that the hydroelectric developments would be limited by the present location of railroad lines. Blue-prints were distributed showing the location of the 21 sites.

This third address was given by C. C. Schluederberg who spoke on "The Part United States Industries Must Perform to Enable the Allies to Win the War." The speaker showed the importance of our industries and the tremendous demands being made on them in the preparation of war materials. On the subject of abrasives and alloy steels he showed the vital relation existing between electrochemistry and the machine shop.

"It is an established fact that were it not for artificial abrasives, which, by the way, are prepared entirely in the electric furnace, the present output of automobiles, trucks, airplanes, and all other products of the machine shop would not be possible. It is readily conceivable that our success in this war will be at least in a measure due to our ability to produce abrasives artificially by electrothermal means.

"Coupled with the use of high-speed cutting tools made from alloy steel derived largely from the electric furnace, and the use of similar steel for machine parts where great strength is required, we have a good example of how modern scientific achievements have gradually worked their way into our every-day lives without our being aware of the fact."

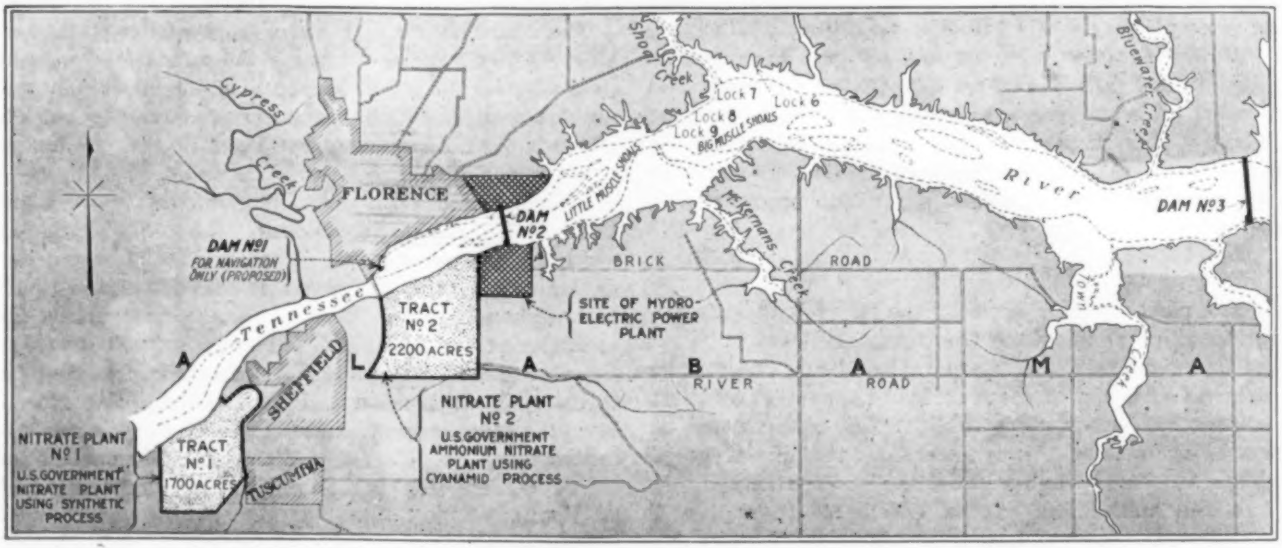


POWER HOUSE AND PENSTOCKS OCOEE NO. 2, TENNESSEE POWER CO.

## Chattanooga, Tennessee

Had time permitted at this point the visitors would have found intense interest in the historic ground of Chickamauga Park, Lookout and Signal Mountains, and Missionary Ridge. Fortunately the local committee had so arranged the itinerary of the morning

[1]Reported by J. E. Shrader at the Pittsburgh meeting of the American Physical Society, December, 1917.




VICINITY OF MUSCLE SHOALS, TENNESSEE RIVER, SHOWING LOCATION OF GOVERNMENT NITRATE PLANTS AND PROPOSED HYDROELECTRIC DEVELOPMENTS

as to afford an automobile ride to these points in connection with visits to industrial plants.

The first point of interest was the plant of the Southern Ferro Alloys Co., which was opened by the courtesy of President Paul J. Kruesi and General Manager George L. Davison, both members of the Society. The company is making 50 per cent ferrosilicon at the rate of 20,000 lb. per day. The plant comprises three single-phase furnaces specially designed by the FitzGerald Laboratories. They are of 833 kw. each, or 2500 kw. for the entire plant. The maximum load for the month of April was 3800 hp. This is the first ferrosilicon plant ever opened to the inspection of visitors, and the courtesy was deeply appreciated.

The party was next taken to the Burdette Oxygen Co. for inspection of the electrolytic oxygen and hydrogen plant. The latter gas is used in the adjacent cotton-seed oil refinery of the Wilson Co. for the hydrogenation of oil.

At the plant of the Chattanooga Gas & Coal Products Co., the Society saw the operation of Semet-Solvay by-product ovens and the recovery of ammonia, tar and light oil. The finished products of the plant are coke, gas of 600 B.t.u., tar which is sold to the Lewis Co., light oil which is sold for fractionation, and ammonium sulphate.

After a trip through Chickamauga Park to a cotton mill and bleachery, the party returned to Chattanooga and went by steamer to the Hale's Bar hydroelectric plant of the Tennessee Power Co. Luncheon was served on the boat.

The dam at Hale's Bar is 1200 ft. long and about 40 ft. high. The power house, shown in accompanying view, contains 14 units of 3000 kw. each, generating current at 6600 volts, 60 cycles, 3-phase. This is stepped up to 44,000 volts for transmission to Chattanooga and 120,000 volts for Maryville, Danville and Ashville.

Returning to Chattanooga, the party was taken to Signal Mountain Hotel where a complimentary dinner was served. Interesting addresses were made by E. M. Jones and T. P. Maynard on the resources of the Chattanooga district.

## Muscle Shoals District

### Florence—Sheffield—Tuscumbia, Alabama

The visit to Muscle Shoals on Thursday, May 2, held unusual interest on account of the immense nitrate plants that are under construction to furnish munitions of war. Here one could gather some idea of the tremendous scale on which the Government has undertaken to provide its requirements of fixed nitrogen. Not only were the visitors impressed with the magnitude of plants, but they came away with a sense of pride in the achievements of American technologists in measuring up to the country's demands. Two huge plants are under construction, and it was learned that the nitrate program will probably call for two more of equal magnitude.

Throughout the day the Society was the guest of the Tri-City community, and members were transported by auto, boat and railroad to see the nitrate plants and the proposed hydroelectric development of Muscle Shoals on the Tennessee river.

A study of the accompanying map will give a clear idea of the full development. In the vicinity of the tri-cities are two Government reservations on which are being built the two nitrate plants, and site for the hydroelectric plant of the future. Three dams are contemplated: No. 1 for purposes of navigation only, No. 2 and No. 3 for development of power. The extent of back water is indicated on the several tributaries to the river.

#### Nitrate Plant No. 1

This plant is being constructed by the Government and will use a synthetic ammonia process developed by the General Chemical Co. and offered to the Government for the period of the war. A part of the ammonia will be oxidized to nitric acid, and the final product will be ammonium nitrate. Expressed in terms of nitric acid the production of the plant will be 200,000 lb. per day. As soon as the present plant is finished it will be duplicated at this point, and it is reported that a similar plant will be built for the Ordnance Dept. of the Navy. The present plant is be-

ing constructed from an appropriation of $20,000,000 made two years ago. The site was located Sept. 10, 1917; construction was ordered on Oct. 1; contracts were signed Oct. 2, and on Oct. 23 the first material arrived. There have been no labor troubles or undue delays. The number of men employed is 2500. In addition to the plant construction, the Government has also built the necessary white and negro camps, commissary, hospital, etc.

### Nitrate Plant No. 2

This plant is being built by the Air Nitrates Corporation acting as agents of the Ordnance Dept., U. S. A., the personnel of the Corporation being practically identical with that of the American Cyanamid Co. whose process has been offered to the Government and is now being installed. It is understood that the proposed plants No. 3 and No. 4 will use the same process.

In the auditorium of the village at Plant No. 2 the Society was addresed by Messrs. Young and Pranke of the Air Nitrates Corporation, who outlined briefly the project. Thirteen thousand men are employed and are housed in temporary camps. A permanent village will provide for 12,000 people. There is a recreation hall for each 800 men in camp, and a "movie" house each for the white and negro population. The mess hall is well organized and arranged and feeds 5000 men in 30 minutes. A modern hospital has been built and a workmen's compensation act is in effect. Sanitation is being provided in an up-to-date manner, and fire and police protection are afforded. Apparently nothing has been overlooked. These brief references give an idea of the human problems, as well as those of mere plant construction, with which the Corporation has been confronted. A complete story of the whole undertaking would make interesting reading and should be written some time in the future.

In the cyanamid plant the lime kilns will burn 350,000 tons of lime per year, and the coke dryers will handle 100,000 tons. The lime and coke are fused in carbide furnaces, the product cooled and ground and placed in ovens of one ton capacity each for treatment with nitrogen. The liquid air plant for nitrogen production will have a greater capacity than all similar plants in the United States and Canada.

The cyanamid contains 20 to 21 per cent nitrogen, equivalent to about 25% $NH_3$. This is cooled, ground and placed in autoclaves where it is treated with steam, producing ammonia. This gas is mixed with air and passed through a heated platinum screen, with resultant oxidation of the nitrogen by catalysis. The oxide gases are then cooled and absorbed. One-half the $NH_3$ produced in the autoclaves will be thus oxidized and combined with the balance of the ammonia for the production of ammonium nitrate. Power requirements will be 45,000 kw., produced from steam at the plant, and 30,000 kw. to be delivered from hydroelectric plants in the vicinity.

Expressed in terms of nitric acid the production of Plant No. 2 will be 2,000,000 lb. per day.

It is noteworthy that this entire process has been tried and proved in commercial operation for some years, and that no experimental equipment or process is being installed. As a consequence it is expected that operations will proceed smoothly from the beginning.

The construction of Plant No. 2 was determined on Nov. 26, 1917, and the first carload of material was delivered Dec. 20. Considering the short time actual construction has been under way, and the variety of work to be done, there can be nothing but admiration for the results.

J. G. White & Co. are constructing the power house at Plant No. 2 and the buildings at No. 1 with the exception of the acid plant. The Chemical Construction Co. is building the acid plants at both No. 1 and No. 2. Westinghouse Church Kerr & Co. are constructing the buildings at No. 1. Officers in charge at No. 1 are: For the Government, Capt. R. W. Hemphill; for the contractors, J. G. Munson and T. C. Oliver. At No. 2: For the Government, Capt. S. L. Coles; for the contractors, G. W. Burpee, M. T. Thompson and T. C. Oliver; for the Air Nitrates Corporation, J. W. Young.

### At Lock 6, Muscle Shoals Canal

As will be seen on the accompanying map, a ship canal extends along the north bank of the Tennessee river. This canal with its nine locks, as well as considerable surrounding land and river islands, will be submerged when the proposed Dam No. 2 is built at the point shown.

It was at Lock 6 on the canal that the Society was tendered a barbecue luncheon following the visit to the nitrate plants. Here with a background of posters showing graphically the various phases of the whole Muscle Shoals project, a number of important addresses were made. C. W. Ashcraft welcomed the Society on behalf of the Tennessee River Improvement Assn., and presented Col. J. W. Worthington, who is generally known as the father of the Muscle Shoals project. He told of the long years of effort to accomplish in the South what had been done at Niagara Falls in establishing an electrochemical industry. He found a warm response to his claim that we need fewer lawyers and more engineers in Congress.

Mr. C. A. Winder addressed the Society on the subject of hydroelectric power. If power-consuming industries are not established contemporaneously with power development the latter is useless. Electrochemical and metallurgical industries offer the best load for hydroelectric plants. The speaker condemned the development of hydroelectric current for domestic and small industrial uses merely on the score that coal would be saved. Such a development might not be able to sell power enough to pay the interest on the investment which normally would be three times that for a steam plant. If the connected load does not consume power every hour of the day there is an economic waste and if it does not consume production for at least 40 per cent of the time the development is a poor venture. Domestic loads for lighting, heating, street railways and light industrial uses should be excluded from hydroelectric loads. Such loads of short duration apply to steam plants where the investment charge is small.

Mr. N. T. Wilcox of the Mississippi Power Co., Keokuk, Ia., spoke of the difficulties originally encountered in developing that project, and encouraged those in charge of the Muscle Shoals project to persevere. He said Alabama was more favored than Iowa in

mineral resources with which to foster industries that would consume power.

Mr. WILLIS G. WALDO spoke briefly on the Muscle Shoals project, stating that there could be a total development of 660,000 hp.; that the nitrate plants and other consumers would take 260,000, leaving 400,000 available for new electrochemical industry.

Mr. FUNASOHU ISOBE, chief engineer of the oil department of Suzuki Co., Japan, spoke for the Japanese who were in the party, expressing their appreciation of the courtesies shown them, and inviting the Society to Japan after the war.

After the exercises the party returned to Florence by way of railroad to Lock 9 and boat to the landing. In the evening a complimentary dinner was served, followed by an informal reception and addresses at the Elks' Home.

## Birmingham, Alabama

This point in the South has long been famous for its combination of such raw materials as coal, iron ore and limestone in close proximity, and for low cost of producing pig iron. Recently the iron and steel industry of Birmingham has expanded, and the Tennessee Coal, Iron & Railroad Co. is building a model industrial town at Fairfield in connection with the new steel-plate plant. The operations of this company show that it thinks in terms of human beings as well as vast machines and furnaces.

The first point visited was the blast furnace and steel plants of the Tennessee Coal, Iron & R.R. Co. Most of the operations here were familiar to the guests, but it was a pleasure to inspect so clean and orderly a plant and see the various provisions made for the safety of the employees. The route of the party through the works was clearly marked by a trail of white sand—a convention "kink" that can well be adopted elsewhere.

From this point the party was taken by auto to the Bayview reservoir of the company, where a barbecue luncheon was served and a brief address delivered by Ex-Gov. EMMETT O'NEAL. In the afternoon the by-product coke-ovens were inspected and the new Fairfield steel works were seen in process of construction. A visit was also paid to the works of the American Steel & Wire Co., to see the manufacture of nails, barbed wire and woven wire fence. A short stop was made at the Birmingham Country Club for light refreshments, and later in the evening a complimentary banquet was served at Hotel Tutwiler.

### TECHNICAL SESSION

The opening paper dealt with the mineral resources of Alabama prepared by EUGENE A. SMITH, State Geologist. Dr. Smith showed that in 1916 the value of the State's raw mineral production was $37,729,136, while the value of derived products was $55,256,735.

### Electrodeposition of Manganese and Manganese Dioxide

Ten papers in all were presented at this session. The first was on the "Electrolytic Behavior of Manganese in Sulphate Solutions," by G. D. VAN ARSDALE and C. G. MAIER, respectively consulting chemist, and research chemist of the Phelps-Dodge Corporation.

This paper presents some preliminary results of work done in an attempt to solve the problem along electrochemical lines. Methods which might be developed from the results presented in this paper will probably not be adapted to the production of manganese for ferro-manganese, or other large-scale metallurgical use, but the data obtained are of interest not only theoretically but may also be of practical use for the production of manganese dioxide, particularly for dry-battery use. The results are summarized by the authors as follows:

*(A)*

1. Mn may be deposited at the cathode, from neutral solutions with high-current efficiency, from 80-90 per cent, and at voltages from 3 volts up.

2. The effect of increase of acidity is practically to prevent the deposition of Mn at a concentration of 0.36 per cent free $H_2SO_4$.

3. The deposit is powdery, and ordinary expedients for improving deposition do not give better results to any great extent.

*(B)*

1. $MnO_2$ may be deposited at the anode at nearly 100 per cent efficiency.

2. The effect of acid is to decrease the efficiency in cold solutions, but on heating to 65°-75° C. there is very much less effect.

3. $MnO_2$ may be deposited from warm acid solutions containing more than 5 per cent $MnSO_4$ in the form of a dense, black, lustrous film, at current densities up to 25 amp. per sq. ft. (275 per sq. m.) with very high deposition efficiency.

4. Impurities which are reducing agents cause a decrease in current efficiency in proportion to the amount present. Methods of controlling practically the effects of deleterious impurities and the possibilities of a commercial method of treating low-grade ores, and producing a high-grade $MnO_2$, will be the subject of a later paper.

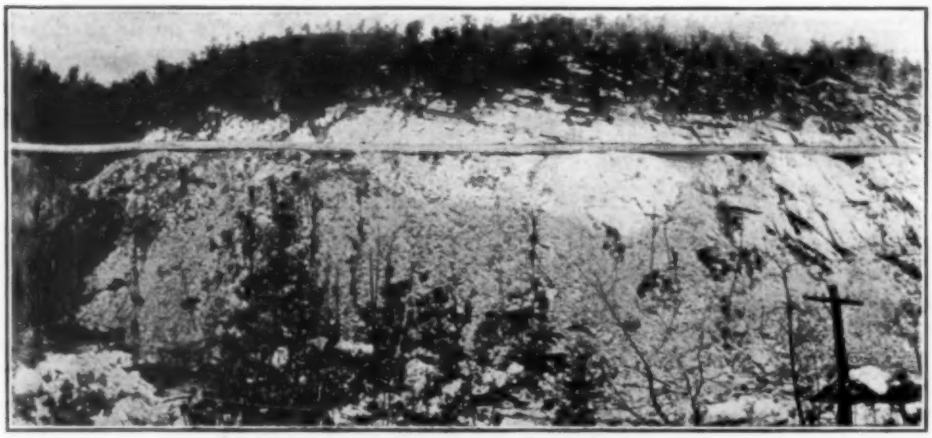
### Electrolytic Copper

The effect of iron sulphate in the electrolytic precipitation of copper from sulphate solution with insoluble lead anodes was discussed in a paper by Prof. EDWARD F. KERN of Columbia University. He found that the presence of iron reduces the efficiency in the electrolytic precipitation of copper from sulphate solutions, when insoluble lead anodes are used. The higher the percentage of iron in the electrolyte, the lower is the current efficiency, and vice versa. The smaller the amount of copper in the electrolyte, the greater is the reduction of current efficiency as the result of the presence of iron sulphate in the solution. The effect of temperature upon the deposited copper is that smoother and purer copper is formed at 50 deg. C. than at lower temperatures. When no iron is present in the electrolyte, the copper may be almost completely removed, and the current efficiency remain very high, even though the copper in solution may be reduced to as low as 0.2 gram per 100 cc. Iron in the copper sulphate electrolyte causes the copper to deposit less smooth and less dense, irrespective of the ratio of current density at anode to that of cathode. It was seen that less adherent and less dense copper was deposited on the cathode from the electrolytes which contained iron than from electrolytes which contained no iron

and which also contained far less copper. The effect of the presence of iron in the electrolyte is to reduce the voltage required for the electrolysis. When no iron was present the potential between anode and cathode was approximately 2 volts; whereas when iron was present it was lower, in most cases being approximately 1.8 volts.

### Copper Electroplating

Experiments with the copper cyanide plating bath were described in a paper by Prof. FRANK C. MATHERS of Indiana University. It was found that the current-yields (ampere efficiencies) at the cathodes were generally lower than those at the anodes, hence the necessity of making the regular additions of sodium cyanide to the baths. Sodium carbonate and perhaps sodium sulphate are valuable additions to the bath. In baths containing near to the minimum of sodium cyanide, sodium hydroxide lowered both the anode and the cathode yields. The anode yields are high in both



FLUME, OCOEE NO. 2, TENNESSEE POWER CO.

hot and cold solutions if a proper quantity of sodium cyanide is present, but the cathode yields are much lower in the cold solution than in the hot. A bath containing 6 oz. (4.5 per cent) copper cyanide, 5.7 to 6.3 oz. (4.3 to 4.7 per cent) sodium cyanide and 5.8 oz. (4 per cent) sodium carbonate per gallon operated at 160 deg. to 175 deg. F. (60 to 80 deg. C.) is recommended. This is more concentrated than the baths generally used, but it can be operated at a higher current and the deposits are much better.

Mr. G. B. HOGABOOM criticized the high temperature used, stating that the deposits would be brittle and unsuited to work where bending or soldering were necessary. Furthermore the decomposition of cyanide is too great at 180 deg. F. As to the concentration of solution used by the author, he felt that 3 oz. Ag per gal. would give better results than 6 oz. The latter solution would be certain to yield blisters if used on steel. As for addition agents, NaOH is useless; $Na_2CO_3$ is useful to "age" the solution, but once added must not be added again. In fact it will increase with time, and hot solutions tend to accentuate this result. At 180 deg. F. a solution will increase from 11 deg. to 30 deg. Be. in three months. He was quite certain that the author's recommendation of a solution containing 5.3 ounces of sodium carbonate per gallon would not give good commercial results as far as the deposit is concerned.

### Magnesia-Silica Refractories

The results of tests on the "Crushing Strength of Magnesia-Silica Mixtures at High Temperatures," were described by Prof. O. L. KOWALKE and O. A. HONGREN, of the University of Wisconsin. The mixtures were made from magnesia running 99.92 per cent MgO and silica running 97.66 $SiO_2$, the balance being lime, iron oxide and water. The mixtures were moistened and pressed into cylinders in a hydraulic press under a pressure of 1500 lb. per sq. in. They were then dried at 2100 deg. C., cut to 1 in. diameter and put under a uniform static load of 66.5 lb. per sq. in. and heated at a uniform rate until they failed. The general summary of results follows:

Pure magnesia failed under a load of 66.5 lb. per sq. in (4.65 kg. per sq. cm.) at 1,680 deg. C.

The addition of silica to magnesia, with seven to eight per cent silica as a maximum, increased the mechanical load-carrying capacity, so that failure occurred only at about 1870 deg. C.; which is approximately 190 degrees higher than magnesia supported.

The failure of magnesia cylinders is slow and gradual; that of magnesia-silica cylinders is abrupt.

The superiority of magnesia-silica mixtures with 7½ per cent silica, over pure magnesia, in mechanical load-carrying capacity, appears to be due to the envelope of forsterite, which cements the grains of periclase.

Above 2000 deg. C. carbon attacks magnesia-silica mixtures very rapidly with a marked loss in weight.

### Electrolytic Tin

A record of experiments to determine the best electrolyte, the best current density and the best addition agent to use in electro-refining impure tin bullion, with the object of saving the precious metals and getting pure tin was given by Prof. EDWARD F. KERN of Columbia University.

The experiments upon which this paper is based were conducted by Mr. FAN CHEN in the Electrometallurgical Laboratory of the School of Mines of Columbia University. The work was undertaken with the idea of finding a suitable tin electrolyte, and the proper working conditions for electrolytically refining tin bullion, so as to obtain the tin as an adherent, dense, compact cathode deposit.

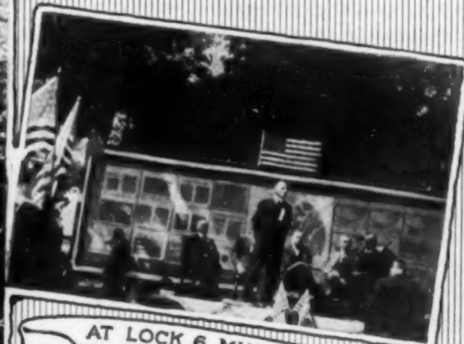
The anodes were crude tin, cast into thin plates 4 inches (10 cm.) long, 1¾ inches (4.4 cm.) wide, and ⅜ inch (0.94 cm.) thick. Analysis gave (in per cent) 96.0 tin, 0.5 iron, 0.1 arsenic, 0.2 antimony, 2.0 lead, 0.6 copper, 0.1 bismuth, and 0.5 silver. The cathodes were made of sheet tin 1/64 inch (0.4 mm.) thick, and larger than the anodes by a quarter of an inch (0.6 cm.) on each of the two edges and bottom.

The electrolytes which were selected for trial were solutions of stannous chloride ($SnCl_2$), sodium-stan-

# GLIMPSES of SOUTHERN TRIP
## *American Electrochemical Society*


AT LOCK 9, MUSCLE SHOALS CANAL


BARBECUE AT BIRMINGHAM


AT LOCK 6, MUSCLE SHOALS


BARBECUE AT LOCK 6


TUSCUMBIA, ALA.


DAM AT CHEOAH


APPROACHING ROTHERWOOD FARM

nous chloride ($SnCl_2.2NaCl$), ammonium-stannous chloride ($SnCl_2.2NH_4Cl$). Magnesium-stannous chloride ($SnCl_2.MgCl_2$), sodium-stannous fluoride ($SnF_2.2NaF$), stannous fluosilicate ($SnSF_6$), and a mixture of acid solutions of stannous fluoride and fluosilicate. Each of these solutions was prepared to contain 5 grams of tin per 100 cc. The experiments led to the following conclusions:

Addition agents are necessary for the electro-deposition of dense adherent deposits of tin.

Stannous fluosilicate electrolyte is the best of the electrolytes tried for the electrolytic refining of crude tin. Free hydrofluoric acid and free hydrofluosilicic acid are beneficial; HF 60 per cent of the total acid content is not detrimental.

The deposits of tin which are formed in sodium-stannous chloride, ammonium-stannous chloride, and stannous chloride electrolytes are similar, when addition agents are present.

Aloin was found to cause the formation of the best deposits when added to stannous fluosilicate electrolytes, in amount corresponding to 1 gram per 500 cc. of electrolyte.

Peptone, when added in amount of 1 gram per 500 cc. of electrolyte, gave good deposits from all of the electrolytes reported in Tables II, III, IV, and V.

Gelatine, quinoline and oil of cloves, when present in amounts of 1 gram per 500 cc. of electrolyte, did not improve the deposition of tin, except in the case of the stannous fluosilicate electrolyte.

Boric acid, when added in amounts of 1 gram per 1500 cc. of electrolyte and up to the saturation point, did not improve the electro-deposition of tin, except when added to stannous fluosilicate electrolyte in amount corresponding to 1 gram per 1000 cc. of solution.

Mr. WITHERELL sounded a note of caution against the use of addition agents, saying that they frequently worked well for a while, but that after a few weeks trouble would come, due to the decomposition of the agents, particularly those of organic nature. These troubles cannot be discovered in the laboratory, and hence it is advisable to use addition agents in only part of the plant at any one time.

### Rusting of Rails

Under the title "Why Busy Rails Do Not Rust," Prof. OLIVER P. WATTS, of the University of Wisconsin, reviewed at length observations made since 1843 on the fact that idle rails appear to rust faster than busy ones. He gave the following explanations offered by previous writers for the lessened corrosion of rails in use:

1. That vibration causes shedding of rust and so, in the presence of less of this stimulator of corrosion, rusting will be diminished.

2. That vibration breaks up areas of different potential that are naturally present on the surface of iron or steel.

3. That there is a voltaic action between bright or polished and dull or rough iron which, in some manner not explained, lessens the total corrosion of the rail.

4. That the rise in temperature produced by the passing of trains causes a more rapid evaporation of moisture from the used rails, and for this reason lessens corrosion.

Prof Watts' results showed that an e.m.f. exists between the top and other portions of used rails acting in such a direction as to protect the rest of the rail; but it is manifestly impossible that a current generated by corrosion of one part of a bar of metal in a single solution shall, by its protective action on the other part, lessen the total corrosion.

The author presents the view that the lessened corrosion of rails in use is due to a combination of two of the causes mentioned by previous writers, viz., voltaic action between strained and unstrained metal in the rail, which results in a slower formation of rust on the cathodic portions, and that thereby the normal accelerative action of rust is greatly diminished; and the complete removal of rust from the top of the rail, where it would otherwise form most rapidly and exert the greatest accelerative effect on rusting.

### Electric Furnaces

The **Vom Baur arc furnace**, a new design, was described by C. H. VOM BAUR, consulting engineer of New York City. The furnace is particularly designed for melting ferromanganese or ferrosilicon, or melting down cold charges for steel castings. The furnace design was created after observing many different electric furnaces in operation, and also operating many of them. It is covered by U. S. Patent No. 1,252,633, and was designed to remedy several defects of previous arc furnaces of the simpler, polyphase, solid bottom type.

It has a 2-phase, 3-wire connection, with the three electrodes in a straight line, the center electrode carrying the heavier current, all contained in an oval-shaped hearth, which has an equal heat gradient at the slag line. As the design follows easy, natural lines, furnaces as small as ½-ton and as large as 15 tons are now being made. In the larger furnaces, the rolling features of the Wellman type have been adopted, whereas with some of the smallest the tilting is accomplished, keeping the spout almost stationary, by having the fulcrum directly beneath it, which facilitates pouring into small hand-ladles.

The advantages of this shape of hearth, together with the 2-phase, 3-wire connection, and the electrodes in a straight line, are claimed to be many and far reaching. For instance: when burning in a basic bottom, as the electrodes are in a straight line, the heat of the arcs can be transmitted to a scrap carbon electrode lying horizontally on the bottom directly beneath all three vertical electrodes, and thence to the basic layer being sintered. Whereas, with arc furnaces having their three electrodes placed in triangular form, or those using four electrodes in a rectangular form, two carbon blocks at least are necessary in order to bring the electric arcs into play for sintering in the bottom. Other advantages in melting down and in minimizing heat losses were explained.

The **Booth-Hall electric furnace,** also a new design, was described by W. K. BOOTH, general manager of the Midland Electric Steel Co., Terre Haute, Ind. It is a vertical arc furnace with conducting hearth and

is built either single-, two-, or 3-phase to suit the conditions at the place of installation, the general principle being a furnace having a solid hearth which becomes conductive of electricity when hot, and the use of an auxiliary electrode which acts as a return for the electric current until the hearth becomes heated and conductive. The furnace is particularly

INTERIOR OF FLUME FOR OCOEE NO. 2, TENNESSEE POWER CO.

intended for melting down cold charges for steel-casting foundries. An illustrated description was published in METALLURGICAL AND CHEMICAL ENGINEERING, February 15, 1918, page 211.

### Electric Steel Castings

A continuation of a report of foundry experience making electric steel castings was given by R. F. FLINTERMAN, of the Michigan Steel Castings Co. The former report was read at the Detroit meeting in May, 1917, and was published practically in full in our issue of May 15, 1917. In this paper a process referred to as "reversed duplexing" was mentioned as having great possibilities and it was intimated that this process would be tried out. In the present paper Mr. Flinterman says the process has not been tried out, as they have been able to increase their tonnage to such an extent with their present furnace that the addition of another furnace would not be economical. An inspiration for a change in furnace construction was derived from the paper by A. A. Meyer on "Electrical Characteristics of Electric Furnaces," which was also presented at the Detroit meeting in May, 1917 (see this journal. May 15, 1917). In this paper several causes of high-voltage drop in the bus bars were discussed and these were made the basis of changes in Mr. Flinterman's Heroult furnaces.

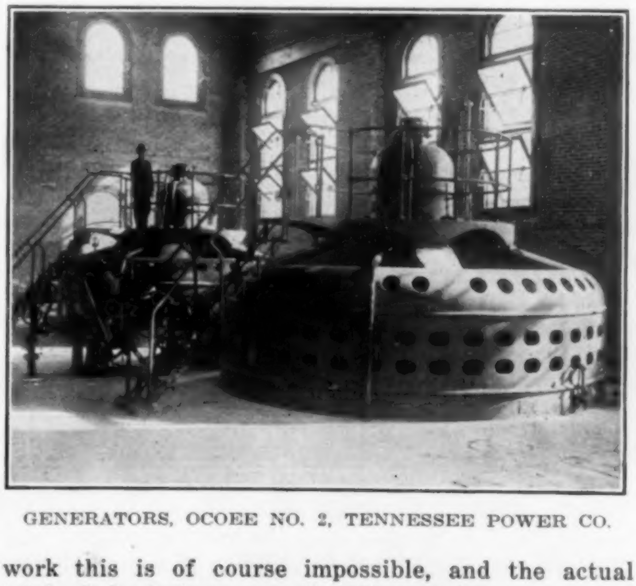
We quote from his paper as follows:

"In case of both the bus bars between the transformers and the flexible cables, and also the bus bars on the furnace itself, the ¼ x 6 in. (0.6 x 15 cm.) copper bars were spaced by means of ¼ x 3 x 6 in. (0.6 x 7.5 x 15 cm.) copper spacers. These spacers have all been replaced by vulc-asbestos spacers. In addition, mica insulation was placed between the various bus-bar leads in such a way that the different parts were isolated and made to act as nearly as possible independently from one another. We find that these small changes have made a great change in operation of furnace. From all indications it would appear that the drop in voltage found by Mr. Meyer has been much reduced. This point will be more clearly established by a series of tests which will be undertaken in the very near future.

"At any rate, it is safe to asume that part of the drop was due after all to skin effect, and that it was not entirely due to induction set up in the steel construction at rear and top of furnace, as Mr. Meyer stated in his paper.

"Under the circumstances, it would be much better to do away with the solid bus construction entirely. The later Heroult furnaces are now constructed as is our 3-ton furnace, where the flexible cables are carried direct to the upper part of the steel structure at back of the furnace. It would seem even better to us to carry the flexible cable directly through to the electrode clamps. There would of course be some induction set up in the steel structure, but we do not believe there would be as much voltage drop as there is now. At any rate, as now constructed, our furnaces are running much faster than formerly, and our current consumption is regularly lower than it was before. On one run of 24 hours, 11 heats were taken from the 3-ton furnace. Our average current consumption for the week, including all delays and stops, is running under 625 kw. hours per ton. Since our work is light, and our metal must be brought to a very high temperature, we consider this a very low consumption.

"With our tonnage brought to this high figure, our floor capacity is taxed to the utmost. An additional furnace would therefore be superfluous and uneconomical. The only opportunity for 'reversed duplexing' in our own shop would be to change the 3-ton furnace to basic lining. Under present pressure of



GENERATORS, OCOEE NO. 2, TENNESSEE POWER CO.

work this is of course impossible, and the actual trial of duplexing must therefore wait.

"There is one other point referred to in the writer's former paper which I desire to touch upon here, namely, the great possibility of the electric furnace in production of the various steel alloys. This one feature is perhaps of greater value and interest to the makers of tool steel, but I am firmly convinced that there are wonderful possibilities in the manufacture of heat-treated alloy-steel castings. This is

a field which is almost untouched and is well worth investigating.

Owing to lack of time the following papers were read by title only:

**Brittleness Produced in Steel Springs by Electroplating,** by O. P. WATTS and C. T. FLECKENSTEIN.

**Experimental Carbon Cell,** by S. A. REED.

**Methods for Commercial Analysis of Ferrosilicon,** by E. M. ANGER.

**Thermoelectric Force of Some Alloys,** by M. A. HUNTER and J. W. BACON.

## Anniston, Alabama

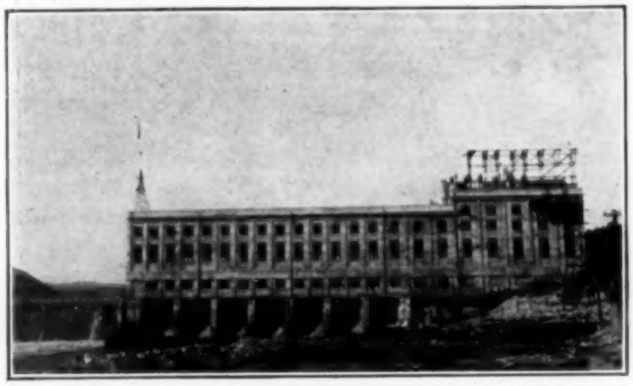
This city was interesting from a technical point of view on account of the manufacture of electric ferroalloys and electric pig iron from scrap.

The Society was entertained at breakfast at the Anniston Inn, after which Mr. THEODORE SWANN, President of the Southern Manganese Corp., outlined the technical features of the local plants. The Southern Manganese Corp. is operating eight 3-phase furnaces on ferromanganese, and in April produced 5 per cent of the United States output. The Anniston Steel Co. is producing pig iron from steel scrap melted in 6-ton Heroult furnaces. Three additonal furnaces of the Southern Manganese Corp. have been leased to another company, which is making ferrosilicon.

Mr Swann stated that they expect to mine all their manganese within eight miles of Anniston and produce 8 per cent of the United States output. They are not looking for bonanzas and expect to get their supply in small lots from mines equipped with one or two log washers and producing up to 10 tons per day each. Such properties can be equipped for $2000 and will be ahead of the game when they have shipped their third carload of ore. Taking the cue from former practice of washing five tons of brown iron ore to get one ton of product, Mr. Swann believed they can afford to wash 50 tons of manganese dirt for one ton of 40 per cent manganese concentrate.

DAM AND POWER HOUSE, OCOEE NO. 1, TENNESSEE POWER CO.

At present the slag from the electric furnaces is being sold to blast furnaces for recovery of the manganese content. Experiments on the retreatment of slag in the electric furnace showed that from slags containing 12 to 14 per cent Mn it was possible to produce a 60 per cent ferromanganese at the third or fourth tap, but the procedure was not commercially profitable. Silicomanganese has been made from the slag pile, running 69 per cent Mn and 19 per cent Si. The product requires more than three times the power necessary for ferromanganese. The furnaces used in the old plant are the type of carbide furnaces of the early nineties. Construction of the new plant was begun on June 25 and was turning out ferromanganese in 23 days. Mr. Swann stated that the company is willing to impart information to anyone who can use it for the benefit of the Government at this time. The plant had thus been opened to the engineers of the Anaconda Copper Co., which recently prepared to make ferromanganese at Great Falls, Mont.



HALE'S BAR POWER HOUSE, TENNESSEE POWER CO.

### RETURN TO WASHINGTON

The special train left Anniston Saturday noon and arrived at Washington Sunday afternoon, where the party disbanded and returned to their homes. The meeting and trip was one of the most successful affairs ever undertaken by a society and was pronounced the best of the meetings of the American Electrochemical Society. It was no junket undertaken for pleasure or personal profit alone, and if the report of the proceedings is replete with items of entertainment, that is to be charged to the inevitable Southern hospitality which had to find expression even in war time. The presence of a dozen ladies in the party added to the pleasure of the tour. They were specially received and entertained at every stop.

The trip was a hurried reconnaissance of a remarkable territory and the sentiment was frequently expressed that a future meeting should be held in the South at a central point. For the excellent arrangements of the trip the Society is indebted to Mr. Charles F. Roth and his committees at the points visited.

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**Iron and Steel of Canada.**—We are glad to welcome a new member to the ranks of metallurgical journalism in America in *Iron and Steel of Canada,* a monthly publication appearing in Montreal in February. The high quality of the publication can be inferred when it is known that Alfred Stansfield, professor of metallurgy of McGill University, is editor in chief. Its field is "the science and practice of the iron, steel, foundry, machine and metal-working industries."

# The Future of the American Electrochemical Industry

BY S. W. MAHER*

IT IS well known that the present center of the electrochemical industry in this country is in the Niagara Falls district, and that the situation there as regards an adequate power supply for the future development of this industry is becoming a very serious problem. In view of this fact it is doubtful if Niagara Falls will remain the center of this industry. Even if it should remain the leading electrochemical district of this country, it is evident that new sources of power must be found to take care of the expansion and development that is already beginning to tax the capacity of the power plants at Niagara Falls. The recent phenomenal growth in the demand for products manufactured by the electric furnace makes the question of great interest to the American engineer and manufacturer.

It is true that the war has brought about an unprecedented demand for electrochemical products, but it is not believed that the industry will decline to any great extent with the cessation of the war. On the contrary, the products of the electric furnace and of electrolysis depend for their demand largely on the ordinary and general growth of industry in this country. The truth of this assertion is easily seen when the chief products made with the help of electric current are considered.

The production of machinery is depending more and more on artificial abrasives, which are important products of the electric furnace. In fact, the value of artificial abrasives is already greater than that of natural ones. Of great importance also are the special alloys used for cutting metals at high speed, and the special steels of various kinds used in so many of the machines that are manufactured today. Aluminium, whose consumption is growing rapidly, and whose uses are just beginning to be understood, is entirely an electric furnace product. Mention may also be made of the electric production of steel, the production of calcium carbide for cutting and welding purposes, and the production of such metals as calcium, magnesium and sodium.

The products of electrolysis in solution are chlorine (which is of the utmost importance to the dye industry), oxygen, caustic soda, and the electro reduction of aromatic nitro compounds. This latter offers a field of great promise as it has yet been little worked on a commercial scale. With the present scope and importance of electrochemical industry, and its future requirements before us, it is proper to refer again to the situation at Niagara Falls. As already stated, this is the center of this field of work in the United States, and as such it is a vital factor to other industries scattered over the country. For instance, the cutting off of abrasives from this point would seriously cripple if not utterly destroy our airplane industry. If continued much longer the apparent lack of appreciation of the importance of the stable and growing electrochemical industry will make itself felt in no uncertain manner. It is believed, with no fear of contradiction, that there is not enough power available at Niagara Falls to adequately support the increasing demand of some of our most important electrochemical industries.

Canada is in a position to control the greater portion of the power supply at Niagara Falls, and in fact has been selling the American manufacturers a considerable quantity. Already, however, Canada's needs are increasing rapidly, and she is, therefore, forced to cut off our supply. As her demands continue to grow, the power situation must become more and more acute for us. In view of these facts, the American electrochemical industry must find other fields where it can expand and grow to meet the requirements of our industrial development.

The ideal site for an electrochemical industry should have not only cheap electric power, but certain raw materials such as salt, lime, coal, bauxite, iron manganese, chrome and nickel. There should also be adequate facilities for assembling the raw materials and distributing the finished products to the market. Of special importance, although not absolutely necessary at the point of production, are such materials as are necessary in the construction and maintenance of electrochemical plants. Among these may be mentioned fireclay, asbestos and mica, as well as refractory materials of all kinds.

Having shown the necessity for seriously considering at this time the future of the American electrochemical industry, attention is now called to a section of our country that we believe offers exceptional advantages for electrochemical plants. We refer to that portion of the southern Appalachian region that lies between the Cumberland Mountains on the north and the Blue Ridge System on the south, and comprising parts of Southwest Virginia, East Tennessee and Western North Carolina. This region offers great advantages in water and steam power, raw materials for manufacturing and building, and has good transportation facilities.

The territory is drained by the waters of six rivers, namely: the Powell, Clinch, Holston, Nolichucky-Toe, Wautauga and French Broad. The primary sources of these rivers are found in the springs, which are supported by abundant rain fall. The rainfall in this part of the country is so heavy and so uniformly constant from year to year that a constant and never failing supply of water power is assured at all times.

The approximate indicated minimum horsepower of these rivers is: Powell 13,000 hp.; French Broad 132,000 hp.; Nolichucky-Toe 61,000 hp.; Wautauga 30,000 hp.; Clinch 34,000 hp.; Holston 47,000 hp. This gives a total minimum indicated horsepower of 328,000. It should be understood that the above figures do not include storage, or any of the tributaries of these rivers.[1]

In addition to the water powers mentioned above, this territory is well situated with respect to the coal fields of Kentucky, Virginia and Tennessee. The amount of coal available from these fields is shown to some extent by the tonnages produced in the respective states in the year 1915. In this year Virginia produced 8,000,000 tons, Kentucky 21,000,000 tons, and Tennessee 5,000,000 tons.[2] These fields possess ample reserves,

*Chemist-Geologist, Carolina, Clinchfield and Ohio Railway.

[1]These figures are taken from "The Water Powers of Tennessee" by J. A. Switzer.

[2]From "Resources of the United States," by the United States Geological Survey.

and are tapped by railroads with strictly modern equipment. This assures a cheap and large supply of first class bituminous coal, which can be transported to prospective plant locations on a very low freight rate.

The mineral resources of this region are very extensive and will furnish many of the raw materials necessary to the electrochemical industry. These minerals are situated on or near the railroad, and, therefore, are easily assembled at points of manufacture. Southwest Virginia offers coal, salt, silica sand and high-calcium limestone, as well as iron and manganese. East Tennessee has commercial deposits of iron, manganese, phosphate and bauxite. Western North Carolina has low phosphorus magnetite, brown hematite, titanic magnetite, nickel and chrome. The proximity of these deposits to the railroad and water powers make the problem of assembling this material a very simple one, and, furthermore, excellent and quick freight service is available for distributing the finished products to the markets of the East, North, South and West.

Building material occurring and produced in this region are Portland cement, brick, tile, sand, lime, granite, sandstone and a variety of timbers, both hardwoods and softwoods.

Other materials that are found in this territory are asbestos, mica, fireclay and other refractories. The hardwoods found so abundantly in this territory are a source of charcoal and acetone, which are of great value. A large wood alcohol plant is now being constructed.

Hence, it is evident that the Southern Appalachian territory offers an interesting field for closer investigation by the electrochemical engineers. It has the necessary factors for cheap power; is has the raw materials, the assembling and distributing facilities, the building material and other advantages of importance to the electrochemical industry.

Johnson City, Tenn.

## Approximate Determination of the Minerals in Concentrates by Means of the Microscope

By Kirby Thomas and Frederick W. Apgar

MICROSCOPIC examination of the concentrates and tailings from preliminary laboratory and mill tests furnishes a ready means of checking operations and observing the results of various adjustments and modifications of process during experimental work. Large-scale mill operation may thus be instituted along most promising lines, avoiding the chance of any radical later rearrangement of plant at considerable cost or the abandonment of a plant which in practical operation was found totally unfitted to the ore at hand. Such examples of wasted expenditure may be found in almost any mining district.

A simple and rapid method for obtaining an approximately accurate quantitative mineral analysis of a concentrate by means of the microscope gives immediate results when they are most wanted, whereas a complete chemical analysis with the calculation involved for recasting in terms of minerals requires considerable time and expense and the results are often delayed until after the immediate necessity for them is past.

A portion of the concentrate which has been reduced in bulk carefully by the application of approved methods of sampling is taken, spread out evenly on a glass microscope slide and placed on the stage. A magnification of 30 to 60 diameters is generally found sufficient for this purpose. The number of grains of each of the various minerals within the field of the microscope may then be counted, at the same time noting the general average size of grain for each.

This operation is repeated from five to ten times over the slide at random points and the results tabulated. Three or four slides may be prepared if desired and two to three counts made on each. If all the grains are approximately equal in size, the *total* number of grains counted of each of the various minerals, reduced to parts per hundred, will represent a percentage *volume* analysis directly; otherwise a simple correction must be applied to allow for the difference in grain-size of the various mineral components.

The relative volume so obtained multiplied by specific gravity and again reduced to parts per hundred will give the desired weight percentage of the different minerals and will be found sufficiently accurate for most practical purposes. The method will take considerably less time than would be required for chemical analysis recast in terms of mineral percentages.

In most cases it will be found that the critical minerals in fragment are easily distinguished by color and surface appearance so that the count may be made very easily and quickly. Certain gangue minerals such as quartz and feldspar are classed together and where two similar appearing dark sulphides occur together in an ore it is not generally necessary to distinguish between them. As a rule milling problems are concerned with the relative proportion of sulphides, oxides, silicates or carbonates and gangue, or with sulphides which differ materially in appearance and gangue.

If a large proportion of the grains are complex in character, minerals included in gangue, the approximation will be less accurate but at the same time perhaps this very fact is of the utmost importance as suggesting the desirability of finer grinding.

TABLE I—MICROSCOPIC ANALYSIS OF FLOTATION CONCENTRATES

Counting all grains in field over 0.03 mm. in size
Considerable dust-like particles from 0.001 to 0.003 mm.
Grains of the different constituents average fairly uniform in size.
Green mineral slightly smaller and quartz slightly larger than the black metallic.

| | No. Grains | % Area | No. Grains | % Area | No. Grains | % Area | No. Grains | % Area |
|---|---|---|---|---|---|---|---|---|
| Green transparent (Chrysocolla) Size 0.03 to 0.12 mm. | 72 | 38.0 | 48 | 34.0 | 57 | 34.0 | 84 | 43.0 |
| Quartz Size 0.04 to 0.20 mm. | 46 | 24.0 | 36 | 26.0 | 32 | 19.0 | 40 | 21.0 |
| Brown transparent Size 0.1 mm. | 1 | 0.5 | 1 | 0.7 | 1 | 0.6 | 1 | 0.5 |
| Red transparent (Cuprite) Size 0.03 to 0.08 mm. | 2 | 1.0 | 0 | 0.0 | 2 | 1.0 | 2 | 1.0 |
| Black Metallic Size 0.03 to 0.17 mm. | 70 | 37.0 | 48 | 34.0 | 73 | 43.0 | 64 | 33.0 |
| Bronze to yellowish Size 0.08 to 0.15 mm. | 0 | 0.0 | 7 | 5.0 | 3 | 2.0 | 4 | 2.0 |
| | | 100.5 | | 99.7 | | 99.6 | | 100.5 |

A typical example of the results obtained by this method on concentrates from a flotation experiment is given in Table I. The approximate results would indicate that by bulk the copper minerals in the concentrate were about 79 per cent, distributed as indicated, which by calculation would show a weight content for the concentrate of copper minerals of from 85 to 90 per cent. Further calculation if necessary will indicate the metallic content.

# Milling in Cyanide Solution

## A Comparative Analysis of the Results of Milling Gold and Silver Ores in Cyanide Solution in Place of Alkaline Water; and the Relation of Amalgamation in the Selection of Method

By A. W. ALLEN

THE object of the present article is to bring forward the pros and cons of milling in cyanide in place of alkaline water as a diluent of the ore and pulp in wet-crushing and grinding operations.

One of the chief advantages accruing from the practice of milling in cyanide solution is the intimate contact resulting between coarse metal and solvent, caused by the action and operation of the grinding machinery. This advantage shrinks in importance in the case of amalgamable ore when consideration is paid to the fact that milling in cyanide precludes the possibility of amalgamation being practiced, or renders its function only partly effective. If any quantity of the metal in an ore can be obtained by a simple and direct method an explanation is needed for the substitution of a complicated solution alternative which actually recovers only a proportion.

In the case of gold ores and in spite of clear enunciations of the actual facts disclosed by milling results a good deal of misapprehension exists; and the question has been complicated and the issue beclouded by reference to the efficiency of amalgamation with unamalgamable gold ores. Such considerations do not affect the question. If a proportion of the gold in an ore is amalgamable then practically 100 per cent of this proportion is recoverable. If cyanidation replaces amalgamation as a treatment process for this proportion, then only from 90 to 95 per cent is usually recovered.

The arguments advanced in favor of part amalgamation have, as far as I am aware, only been used as referring to amalgamable gold; and it is therefore an untenable claim to advance that this gold may not amalgamate. In special but exceptional cases the recovery of gold by cyanidation may reach 97 per cent, but in no single instance has a recovery of 100 per cent been recorded with any professional claim to verisimilitude. These facts may be substantiated by milling barren material similar in physical characteristics to the ore usually found in gold treatment plants, and mixing with this a proportion of coarse gold recovered by the amalgamation process. No matter how fine the ultimate division of the mixture there will remain a small percentage of the original amount of gold associated with the gangue after complete milling in cyanide and filtration treatment.

### Extraction Versus Recovery

A second method of beclouding the issue is to draw attention to the total amount of gold dissolved or extracted by cyanide and to ignore the question of recovery. Finely divided gold may be completely dissolved in a cyanide solution and thus completely extracted from the ore; but when associated with gangue as an average grade material such extracted gold cannot be completely recovered by any combination of known metallurgical processes operating on a working scale. All or nearly all the gold may be dissolved and a high percentage may be recovered as bullion. The loss of the balance is all that is needed to influence the contention in favor of efficient amalgamation of gold ores.

A case in point is afforded by the recent publication of the results of treatment in a milling-in-cyanide plant where amalgamation has been abolished. Previous milling operations showed that 86 per cent of the gold could be concentrated in about 7 per cent of the tonnage. Tests on the 93 per cent remaining, constituting the tailing after amalgamation and concentration, showed that this could be reduced to 45 cents per ton by crude cyanide methods, and apparently without further grinding expense. These results would seem to indicate the lines along which a very successful scheme of treatment might be formulated.

The 45-cent residue was, however, considered discouraging and further experiments on a sand of normal fineness for leaching purposes were apparently not considered. Tests were then made to see how much gold could be dissolved by an agitation treatment, and the results indicated that all the gold was soluble provided grinding was carried far enough. "Extractions" of 99.7 per cent were obtained in the laboratory; and as a result of these tests it was decided to grind and regrind the 7 per cent of the concentratable material without separation from the 93 per cent of low-grade ore, a scheme which provided that every particle of worthless rock and absorbent colloid should be thoroughly accepted in as rich a solution of gold as possible.

The fact that all the gold is soluble in cyanide is now reaffirmed, but actual results would seem to indicate that from 40 to 50 cents per ton has been lost in the residue from about 400,000 tons treated by an all-sliming, milling-in-cyanide process.

If the question of the further recovery of gold from the residue is considered it must be realized that the 7 per cent of material which might have been concentrated for special treatment is now intimately mixed with a large tonnage of gangue, and that any additional treatment of this residue may be deemed infeasible by known methods of handling. Even if the ratio of concentration was reduced to 10:1 there would still remain argument in favor of the isolation of the special product. A dump of 400,000 tons of residue carrying about 40 cents per ton in gold is valueless. A dump of 40,000 tons of clean pyritic concentrate carrying about $2 per ton in gold is a valuable asset in sulphur content as well as gold.

Tests on the concentrate in question showed that 96 per cent of the gold could be extracted by straight cyanidation, and apparently without previous roasting, or amalgamation during regrinding. Practical results on pyritic concentrate invariably show that roasting reduces the cost of subsequent grinding and lessens

cyanide consumption. Sulphur is urgently needed at the present time but "up-to-date" methods for the treatment of a simple gold ore involve not only the loss of the pyrite but a recoverable percentage of gold associated with it. By concentrating the pyrite and recovering the sulphur the gold is actually liberated, and the highest possible percentage may then be recovered.

The foregoing example adds weight to the contention that after milling in cyanide and all-sliming the actual residue value is not by any means in inverse ratio to the solubility of the gold in cyanide solution; but rather in direct ratio to the amount of gold which is permitted to pass into solution and become intimately associated with the worthless constituents of the ore. Practical results go to prove that a comparatively high percentage of such soluble gold is lost in the residue after what are generally termed "improved" methods of ore treatment.

### Influence of Colloids in Absorption of Metal

Absorption of dissolved metal by colloid particles plays an important part in the all-sliming process and may be cited as one reason at least for the non-recovery of all the extracted metal. It is no longer possible, in the light of contemporary investigations, to speak definitely of dissolved or undissolved metal after cyanide treatment, when it is impossible to determine how much of the metal has been dissolved and absorbed, and how much has been untouched by the solvent. Reduction in actual recovery as a result of the absorption of metal-bearing solution is a phase of treatment not encountered in amalgamation practice. Absorption and adsorption are phenomena which are largely influenced by the question of fineness of division; and this fact may serve to explain the reason for the comparatively high residual content after milling and fine grinding in a cyanide solution carrying valuable metal, or in which a proportion of the metal is immediately dissolved.

### Amalgamation Inefficient for Silver Ores

In the case of silver ores the advantages are in favor of milling in cyanide and the abolition of amalgamation, other than in exceptional cases such as at Nipissing. The reason is that on normal grade ores amalgamation is an inefficient process at best, a circumstance largely due to the fact that the specific gravity of the metal is comparatively low, and also that it invariably occurs in combinations unfavorable to high extractions by this process.

An additional factor influencing the decision to abolish amalgamation in favor of milling in cyanide with silver ores is found in the circumstance that the finest grinding is necessary in any case, whereas with gold ores it is almost invariably unnecessary, although often adopted to eliminate the need for separate treatments of sand and slime and to simplify the subsequent methods by handling the pulp in one solution and solution-displacement operation.

If regrinding of mill pulp could be done after thickening there would be a field for usefulness in the tube-mill in helping to dissolve gold remaining associated with the ore after efficient amalgamation had recovered its maximum amount. But efficient milling and regrinding usually involves classification and ample dilution, hence milling in water and regrinding in solution is impracticable under ordinary circumstances.

### Dry Crushing Precedes Roasting and Cyaniding

Dry crushing is usually practiced from necessity and not from choice, but this method of reduction is indicated in the case where roasting follows crushing and precedes cyanide treatment. In this instance it has been found an advantage to regrind in weak cyanide solution in an apparatus available for amalgamation. The cyanide present tends to cleanse the gold and assist amalgamation; and as much as 40 per cent of the gold content in refractory ore may be recovered by this method at a minimum cost for labor and material, the balance being in a favorable condition for subsequent cyanide treatment.

### Water Consumption Influences Method of Treatment

On the question of water consumption there are advantages in favor of milling in cyanide in those cases where efficient thickening is out of the question, or where the residue is discharged at under 20 per cent moisture. Under normal conditions, and by inexpensive means, sand tailing may be dewatered to carry the same percentage of moisture as when being dumped. Slime pulp can usually be dewatered by gravitational settlement and thickening to from 25 to 35 per cent moisture, or from 15 to 25 per cent by means of continuous-operation vacuum filters. The residue from decantation or vacuum-filter plants usually carries a fairly high percentage of moisture so that there need be no accumulation of solution, and in most cases there is sufficient balance for a water-wash.

Filter-press dewatering is practiced at the Homestake, Great Fingall, and elsewhere, and illustrates the most exact precision of chemical manipulation. The ore is first amalgamated to reduce coarse-gold content and the subsequent cost of chemical treatment by cyanide. It is thoroughly washed during milling, and lime is added previous to cyaniding to counteract soluble refractories and to assist coagulation. Cyanide treatment is then carried out in the presses on a neutralized slime, and unnecessary exposure to atmospheric influences is avoided, the time of cyanide treatment being limited to a minimum. The result is an extraction and recovery unparalleled in the metallurgy of gold ore and a cyanide consumption well below the average.

With ordinary chamber filter-presses a low percentage of moisture is left in the residue, from 15 to 25 per cent; but where opportunity permits an extensive water-wash it is often advisable to dispense with its use. It has been found that the practice necessitates a much higher cyanide strength than is necessary for the effective solution of the gold; and the loss of cyanide when an appreciable percentage of the moisture in the residue is in the form of barren solution is less than when an attempt is made to retain the whole of the solution, plus the contained double salts, in the circuit. In other words, a reduction in cyanide follows the practice of keeping the zinc content in the solution as low as possible; and the simplest way to insure this is to discharge a small percentage of the solution with the residue as moisture.

With regard to the use of a replacement water-wash with a filter-cake there are few instances where this is practicable. In most cases the time may be better employed in extending the solution-wash. Water will only mechanically displace dissolved gold, but the use of solution may cause residual gold to dissolve as well as replacing gold already in solution. There is also no danger of upsetting the chemical equilibrium of the solution by dilution.

When the residue is being discharged at a high percentage of moisture a final and efficient water-wash is, of course, imperative. Under normal conditions, however, the retention of practically all the solution in a closed circuit, with the constant addition of zinc and other impurities, will eventually result in an increased chemical consumption, and a decrease in actual recovery.

### Questions of Acidity and Alkalinity

A great number of ores have an acid reaction. This acidity should be neutralized before the ore is brought into contact with cyanide solution, more especially if the latter contains gold. This neutralization can be effectively carried out by the adoption of milling in water. If milling in cyanide is practiced there is a loss of solvent from this cause alone which is by no means insignificant when circumstances prevent a high alkalinity being maintained in the solution.

On the question of the degree of alkalinity it is common knowledge that, in the great majority of cases, the amount of electrolyte needed for effective settlement involves a higher alkalinity than is good for satisfactory and economincal precipitation. In other cases a very low alkalinity is required for effective solution of the metal in cyanide. When milling and thickening in cyanide solution is practiced it is generally found that the question of alkalinity for solution and precipitation of the gold must be subordinate to the degree required for effective settlement of the ore. Under these conditions, and especially in the case of an ore carrying a variable clay or schistose content, it is almost impossible properly to control the alkalinity to suit metallurgical requirements without interfering with the mechanical capacity of the settling plant. On the other hand when milling in water is practiced a fairly high alkalinity can usually be maintained in the milling circuit with its attendant advantages of improved amalgamation, more effective settlement of the slime, and a clearer overflow for battery-water service. At the same time a thicker discharge can be obtained from the dewaterers. On account of the lower water percentage in the thickened sludge the resultant alkalinity of the pulp, after having been thinned with plant solution, is so low that alkalinity control is then an easy matter, and can be adjusted to a nicety to suit metallurgical and chemical requirements.

These remarks with reference to latent acidity in the ore also apply to the numerous instances where the ore contains reducing agents, raw or partly oxidized pyrites, or other compounds whose detrimental effects on a cyanide salt, or on a solution of metals of uncertain stability, would be wholly or partly neutralized by the preliminary treatment with lime or other alkali. In the case where the available water is acid or naturally impure, the cost of preliminary treatment may often be avoided by milling in lime-water; and a number of the troubles encountered from such a source may be overcome by the addition of sufficient alkali in the battery.

### Disadvantage of Large Volume of Metal-Bearing Solution

A further disadvantage of milling in cyanide lies in the fact that the necessary quantity of metal-bearing solution must be very largely increased, and accurate control rendered more difficult. The metal in the battery solution can only be reduced by an increase in the tonnage precipitated, involving further consumption of cyanide and zinc. If the practice of milling an acid ore in a cyanide solution carrying an appreciable quantity of metal is to be avoided, then all the solution coming from the mill should be precipitated. When sliming follows milling it is often difficult, if not unwise, to keep the dilution below 1:10; and the latter figure multiplied by the tonnage would possibly underestimate the amount which ought to be precipitated. In general practice, however, a compromise is usually effected. A part of the solution is precipitated, and the possible ill-effects of bringing the remainder of the dissolved metal in contact with raw ore is not taken into account. The result is in favor of premature precipitation, colloidal absorption of dissolved gold, and a decrease in the net recovery in the plant.

The loss of cyanide due to the necessity of bringing moisture in the crushed ore up to general average cyanide strength has been estimated on the Rand to amount to 0.12 lb. (KCN) per ton of ore. But as the total cyanide consumption on this field, where milling in water is almost entirely practiced, amounts to 0.3 lb. per ton, it is obvious that there are economical advantages in favor of milling in water which greatly outweigh the loss of cyanide from the above cause.

The restricted limit to cyanide operations as a result of milling in water is doubtless responsible for the very low average cyanide consumption; and recent experiments have shown that this could be halved by minimizing the contact of cyanide solution with the air, i. e., by closing-in the plant.

### Chemical and Mechanical Loss of Cyanide

In milling-in-cyanide practice the exposure of large tonnages of solution to deleterious atmospheric effects, accompanied as it is in many cases by violent agitation in milling apparatus, is also responsible for considerable chemical loss of cyanide due to the evolution of hydrocyanic acid—a gas whose presence is not difficult to detect in many plants.

As regards chemical loss of cyanide J. W. Hutchison[1] stated that, with reference to Goldfield Consolidated results, a marked increase was indicated by adopting milling in cyanide, the conclusion being confirmed by a three-weeks' test. W. P. Lass also stated,[2] in connection with the preliminary work with Alaska Treadwell ore, that previous agitation with alkali saved 25 per cent of the cyanide consumption. E. M. Hamilton has shown that,[3] in treating a concentrated pyritic material, direct cyanidation caused a loss of 100 lb. of

[1]Eng. & Min. Jour., Vol. 94, p. 170.
[2]Min. & Sci. Press, Oct. 21, 1911.
[3]Eng. & Min. Jour., Vol. 93, p. 840.

the solvent per ton, an amount subsequently halved by preliminary treatment with lime-water.

Mechanical loss of cyanide when milling-in-water is practiced is largely influenced by the effectiveness of the dewatering equipment. On the other hand an almost complete displacement of the cyanide solution from the residue may result in fouling, which necessitates a higher cyanide strength in the solution and a greater cyanide consumption than would otherwise occur.

As a matter of fact some misconception exists with regard to this question. Complete displacement of solution by water in a final wash is seldom or never practiced, and in the great majority of instances is impossible to obtain. The amount of solution ultimately discharged with the residue is, more or less, in inverse ratio to the time spent in water washing, as compared with the time spent in solution washing. In other words if it takes an hour to displace rich solution in a thick cake with barren solution, it will also take an hour to displace the barren solution with water. A five or ten-minute water-wash generally suffices, so that the operator of a leaf vacuum-filter is probably discharging more solution with his residue after a water-wash than a filter-press operator would discharge after solution washing only. If it is admitted that a certain percentage of solution is invariably discharged with the residue, which I think is incontestable, then it is obvious why fouling of solution is more in evidence where milling in cyanide is practiced. With milling in water the solution is more easily controlled and the "barren," with the highest zinc content, is used almost in its entirety for washing after filtration. Hence the largest amount of zinc is sent to the dump in the smallest amount of solution. Where milling in cyanide is practiced a very large proportion of the "barren," containing the highest zinc content, is sent back to the main circuit and distributed over a large bulk of diluent.

The statements which are made as regards loss of cyanide as a result of milling in water are not borne out in practice and the majority of operators whose experience has included both methods with a variety of ores will probably agree that the advantages of a preliminary alkaline treatment by milling in water, the close control of the solution on account of the restricted amount, and the low tonnage to be precipitated, are all favorable factors insuring low cyanide consumption in the treatment of a gold ore.

### Milling in Cyanide Increases Time of Treatment

As regards time of treatment both Mr. Hutchison and Mr. Lass, already quoted, make decisive statements that, in dealing with their respective ores, a longer time was required to effect solution when milling in cyanide was practiced. These results are coincident with my own, and a number of tests convinced me that the gold in mill solution, when brought into contact with fresh ore in a milling plant, was not of so stable a nature as is generally supposed. The tests indicated a great difference when the ore was cyanided after a preliminary alkaline treatment as compared to a similar handling of the residue from the milling-in-cyanide plant after complete treatment. In the latter case further solution from a comparatively high residue only occurred after protracted periods of agitation and then only in minute amounts, the rate of extraction being practically unaffected by replacement of solution. On the other hand when the original ore was agitated direct after a preliminary alkaline treatment, a lower residue was obtained in a very much shorter time.

As facilities for mechanical contact between ore and solvent are far more favorable when cyaniding is commenced in the mill it is probable that this apparent delay in the dissolution of the gold is really due to the fact that absorption, adsorption, and possibly re-precipitation of the metal accompanied its solution by cyanide. It may be assumed that the final "extraction" point is delayed until the re-precipitated or absorbed gold has been re-dissolved; and also until as much as possible of the absorbed metal-bearing solution has been osmotically removed by continued contact with a solution of different strength. These final phases would be slow-acting processes and the theory may account for the apparent delay in the extraction of gold from ore after it has been milled in a cyanide solution containing gold.

### Effect on Gold Rfcovery

With regard to the question of gold recovery percentage by both methods Mr. Hutchison stated that, at Goldfield, crushing in alkaline water followed by cyanide treatment resulted in an increase of two per cent in the extraction, as against milling in cyanide. On the other hand, and dealing with the case of an amalgamable gold ore, the loss in actual recovery would be proportionate to the amount of gold which could have been extracted by amalgamation.

The Alaska Treadwell tests showed equal extractions with straight cyanidation as compared with cyanidation preceded by amalgamation; from which it may be deduced that practical methods would favor the inclusion of the latter process if net recovery only was taken into consideration. The final conclusion, however, is generally dependent on a number of other factors which might deflect the decision in favor of milling in cyanide.

Further complications arise in the matter of the clarification of the solutions where milling in cyanide is practiced. Clarification may often be effected with a sand filter after milling in water. The finely divided colloid which is in so many instances a feature of the solution after milling in cyanide may be coagulated by using excess of lime. Under such conditions the degree of alkalinity which it is necessary to maintain in the solution has a prejudicial effect on precipitation.

### Efficient Sampling Favors Milling in Water

In the matter of sampling any decision will be overwhelmingly in favor of milling in water, since the efficiency of the operation is proportionate to the fineness to which the ore has been ground before the sample is taken. This is borne out in assay practice, the assay charge from a sample being the logical equivalent of a sample from a day's run.

There are, of course, mills where an elaborate system of sampling is installed, and where a large proportion of the tonnage is handled and re-ground in the sampling plant. Under such conditions and even with an ore carrying a coarse or variable metal content a good average sample may be obtained, but its representative value is not comparable with a sample of the whole

product that is taken automatically after milling in water. The necessity for the efficient sampling of the ore in a mill cannot be overestimated, and a deal of unnecessary worry and not a little disappointment would be avoided if more attention could be paid to this detail in the first instance. Nothing is more detrimental to the efficiency of operations than the knowledge that no sure conclusions can be arrived at as to the results of the work being carried on, or any reliable forecast made from the assay results of samples of the ore.

### Influence of the Personal Factor

Modern milling practice requires constant attention to details, such as the testing of the pulp at every stage of the reduction process. One deterrent factor in cyanide mills is seen in the trouble caused to operators by the poisonous effects of the solution in circuit. I have encountered three classes of millmen. One of these was immune, and obviously so, from any ill-effects. The second class protested an immunity but took particular care, I noticed, to avoid exposure whenever possible. The third class made no pretence and maintained that unless they took special precautions and often avoided a necessary duty they suffered in no light degree. It is impossible to keep one's hands dry in a wet-milling plant although subsequent cyaniding operations may be efficiently controlled by methods involving the minimum of personal discomfort to the operator, and often with an entire avoidance of contact with solution.

In deciding on a process by a comparison of figures the personal factor is often overlooked; and, unless the millmen selected happen to be in the enviable minority and immune from infection, a serious factor against efficient working is encountered by the adoption of milling in cyanide. Infection may result in symptoms varying from slight rash annoyance to perpetual irritation by day and insomnia by night; and the superintendent must often withhold censure for neglect of duty when he knows that vigilance on the part of the millman would have resulted in increased personal discomfort.

The outstanding features of milling in cyanide may be summarized as follows:

#### Advantages

(1) The milling and regrinding plant offers exceptional advantages for the solution of gold and silver by reason of the intimate contact between metal and solvent.

(2) A saving in water consumption may be effected by milling in cyanide in cases where the settlement of the ore is difficult; where the dewatering units are ineffective; or where the residue is being discharged at under 20 per cent moisture.

(3) A simplification of plant arrangement is possible and separate return-pumping and storage systems for solution and water are unnecessary.

#### Disadvantages

(1) Decrease in amalgamation efficiency where this recovery method is practiced; corrosion of plates; and increased consumption of mercury.

(2) Higher cyanide consumption and longer time required to effect a lower extraction of the metal in the ore.

(3) Increase in the amount of metal-bearing solution in circuit, with greater liability for mechanical loss; and proportionately higher precipitation costs per ton milled.

(4) Liability of neglect in milling and grinding plant operation on account of the poisonous nature of the diluent.

#### Applicability

(1) When no advantage, either economical, metallurgical, or chemical, arises from the use of a preliminary alkaline treatment of the ore or the water used for milling purposes.

(2) When amalgamation, if adopted, would result in an inappreciable saving.

(3) When it is not necessary to fine-grind or slime the ore preparatory to cyanidation, thus obtaining a product which, in residue form, usually contains more moisture than if coarser crushing, followed by leaching, had been adopted.

(4) When dewatering prior to cyaniding, to within a few percentages of the amount of moisture to be discharged in the residue, is impracticable.

Probably no other phase of any chemical-metallurgical process is being operated under so many different conditions as the one dealt with in this article; and for this reason an effort has been made to avoid dogmatic decisions. The conclusions are based on many data and observations of practical operations under an immense variety of conditions with an extensive amount of experimental research, coupled with the available information on the subject.

The necessity for the marshalling of facts and the classification of ideas on this important development is obvious. The subject of milling in cyanide has been barely mentioned even in recent text-books; and the method has often been adopted as a necessary concomitant in the utilization of a specialized process of solution recovery, and sometimes without an apparent realization of the advantages in favor of the alternative method of milling and thickening in alkaline water as a preliminary to cyanide treatment.

New York, N. Y.

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## Technical Association of the Pulp and Paper Industry Meets at Dayton, Ohio

The annual Spring meeting of the Technical Association of the Pulp and Paper Industry will be held in Dayton, Ohio, May 16 and 17, 1918. The particular subject for discussion at the technical sessions is Fuel Economy and Scientific Boiler Room Methods. This subject is of particular importance in connection with the operation of paper mills and it is expected that much information will be brought out for the benefit of the industry. The paper manufacturers of the Miami Valley have arranged for the entertainment of the Association and for the inspection of several of the important paper mills. The meeting is considered important on account of the probable shortage of fuel for paper mills next winter and the necessity of curtailing operations.

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**Proposed Iron and Steel Works for Queensland, Australia.**—The British Board of Trade Journal says that a Royal Commission appointed in 1917 reports that a great deal of research work must be done, and much more information be collected before they can make recommendations with regard to the establishment of a complete iron and steel works. They say, however, that all the essentials are in Queensland for the successful manufacture of pig iron, and that an experimental plant for its manufacture can and should be established (costing roughly $25,000) to test in bulk the available iron ore deposits and to determine the proper site for an eventual iron and steel works. They also believe that the making of pig iron would be a profitable undertaking for the state.

# Washing in Filter Presses

By D. R. Sperry

## Simple Washing, Recessed Type, Separate Inlet and Outlet For Wash

THERE are certain cases in which it is desirable to have the wash-water connection on the filter-press separate and distinct from that of the feed connections. This can be accomplished in the recessed type only with the use of frames. It would be possible of course to put in a duplicate feed-channel composed of a separate set of grommets but such an arrangement is rather too expensive and impractical to be employed. When frames are used a channel is formed by placing an eye in the upper corner opposite the one occupied by the grommet. In Fig. 1 a recessed plate-and-frame filter-press having separate inlet and outlet connections for simple washing is shown in two cross-sections.

The upper cross-section shows that the material to be filtered when introduced into the feed-inlet traverses the entire length of the filter-press passing from frame to frame by way of the openings through the grommets. The chambers bounded by the frames and filter-base, usually canvas, are thus filled with the material to be filtered, the liquid passing through the filter-base and deposited solids on to the surface of the plate and out of the filter-press via the cocks. The solids are allowed to deposit only until there is still an opening between the solids on either chamber wall. The feed is then shut off and the cocks closed. Wash-water is then admitted into the separate wash-water channel.

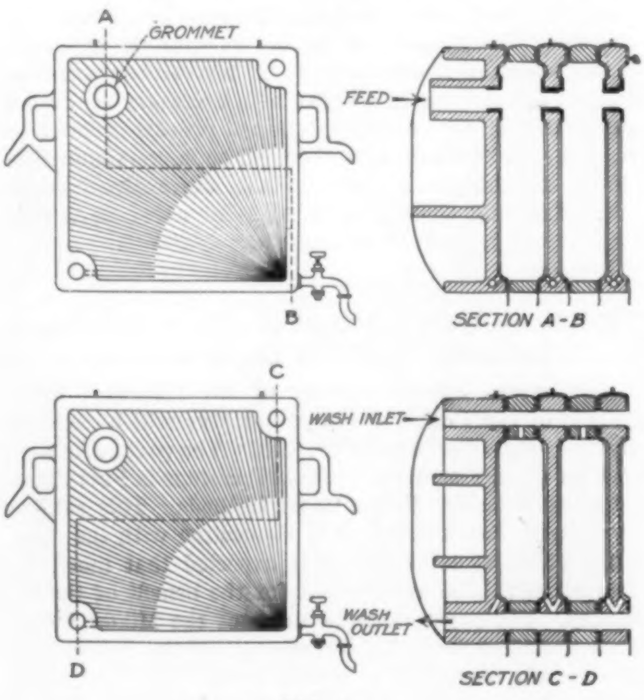

FIG. 1.

The lower cross-section taken through the wash-water inlet and outlet channels shows that the wash-water runs the entire length of the filter-press dropping into each frame by means of the port in the eye of each frame. The wash-water thus brought into intimate contact with the deposited solids, passes through them, against the plate surface and out, not through the cocks as the filtrate did, but through the port in the opposite corner. The ports feed into the wash-water outlet formed by the eyes in the lower corner. The issuing wash-water is thus led to the outside of the filter-press at the point called the wash-water outlet. The frame used in this arrangement is shown in Fig. 2. A photograph of a plate belonging to this system is shown in Fig. 3. For the filtering and washing of certain materials this arrangement is a very convenient one. The feed-channel formed by the openings in the grommets makes a very generous feed opening suited to heavy materials. The fact that the wash-water has its own entrance and exit permits the use of permanent connections and allows the washing to be carried on independent of the filtering process.

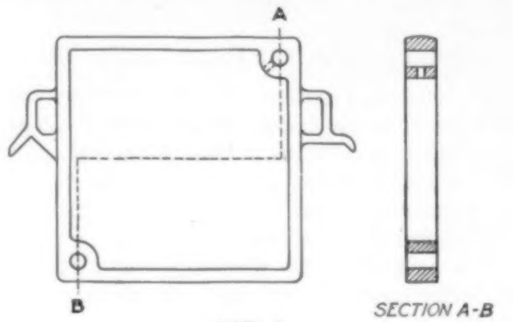

FIG. 2.

## Simple Washing, Flush Plate, Separate Inlet for Wash

In the flush type of plate without grommet feed, simple washing may be carried on having a separate inlet for the wash-water. Such an arrangement is shown in cross-section in Fig. 4. The frame alone is shown in Fig. 5. The upper cross-section indicates that the feed-inlet channel formed by the eye in the corner diagonally opposite the cock, leads the material to be filtered directly to the interior of each frame. Here as in the preceding

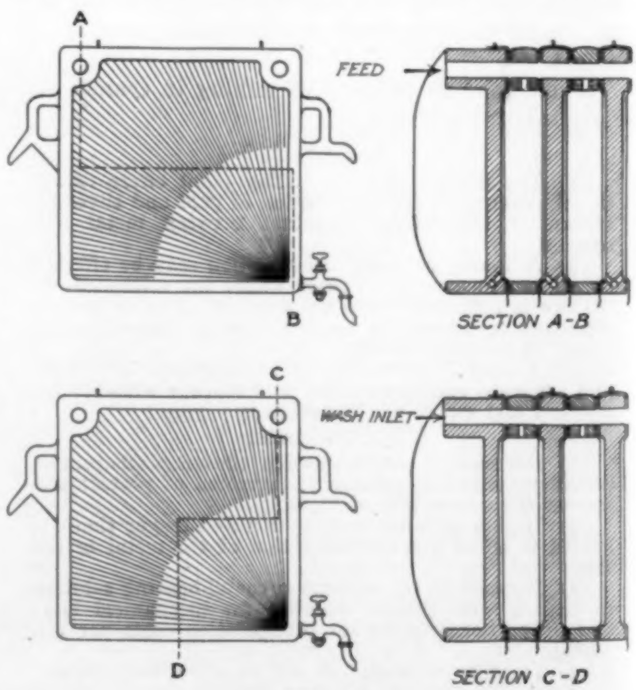

FIG. 4.

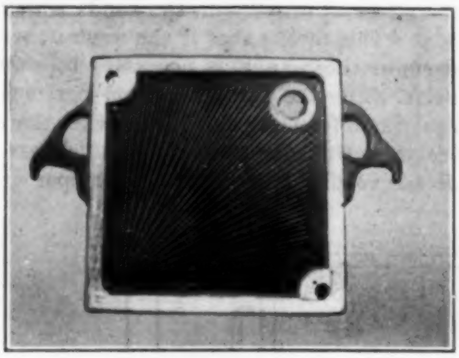

FIG. 3.

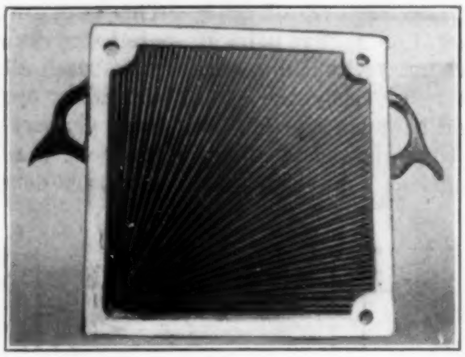

FIG. 11.

case the solids are allowed to build up on the sides of the chamber, usually cloth, only until the two walls of solids still leave an open space between them. The feed is then shut off and wash-water admitted into the wash-water channel.

The lower cross-section shows that the wash-water is conveyed to the open spaces left in the chambers by means of the channel formed by the eye opposite the feed eye. The wash-water passes through the solids against the surface of the plate and out by way of the cocks, precisely as the filtrate did. A view in a filter-press having this arrangement is shown in Fig. 6. The filter-press is opened to show the eyes and is not clothed. In Fig. 7, a photograph of a filter-press showing the head connections as they appear in this arrangement is shown. This type of filter-press is used where the material to be filtered does not bear solids which have a tendency to clog up small openings. The hole connecting the feed-channel with the interior of the frame is ordinarily quite small, hence, it is unwise to use a filter-press of this kind upon heavy materials. An exception to this rule is the case in which the frames are of such thickness that a fair sized port running to the feed-channel is practical.

### Simple Washing, Flush Plate, Separate Inlet and Outlet for Wash

In practice it is often inconvenient to have the wash-water follow the same path as that taken by the filtrate. It is sometimes very necessary to allow no liquid other than the filtrate to come in contact with the cocks or gutter. In such a case a separate outlet for the wash-water must be provided. This can easily be done and arrangement for this purpose is shown in cross-section in Fig. 8. As in the case just given, the upper cross-section shows that the material to be filtered reaches the interior of each frame by means of the channel formed in the upper left-hand corner. When the cake on each side has been deposited only enough to have an open space down the center of the chamber, the feed is shut off and the cocks on each plate and head closed. Wash-water is then admitted into the wash-water channel, shown in cross-section in the lower part of Fig. 8. It can be seen that the wash-water reaches the open spaces left in the centers of the chambers by means of the wash-water port in the corner of the frame.

A separate frame in cross-section is shown in Fig. 9. The wash-water passes through the solids and emerges against the surfaces of the plates. It cannot leave the plate via the cocks, which are closed, as did the filtrate, but it does leave the plate by means of the port in the opposite corner which leads it into the wash-water outlet channel formed by the eyes in the lower left-hand corner. In this manner the wash-water both enters and leaves the filter-press without coming into contact with the cocks or gutter. The connections can be made permanent and the wash-water led to any desired place. In Fig. 10 is shown a photograph of a filter-press arranged as last described. Fig. 11 shows a picture of a separate plate used in this arrangement.

### Closed Discharge for Filtrate

In any of the foregoing cases the filtrate may be caused to issue from a single connection in the fixed head, thus dispensing with cocks on each plate and head. This is called "closed discharge." In such a case there is placed an eye in the corner where a cock would otherwise be placed. This forms a channel the entire length of the filter-press. The drainage from the plates runs into the channel through ports running from the eye to both surfaces of the plate. This is often used where it is undesirable to allow the filtrate to come in contact with the atmosphere, or where it is desirable to elevate the filtrate to a level higher than that of the filter-press.

### Simple Washing in General

In actual practice one does not find many filter-presses using simple washing. There are several objections to it and in the majority of cases the other kind of washing, known as thorough washing, to be described later, is preferable. In the first place it is an exceedingly diffi-

FIG. 6.

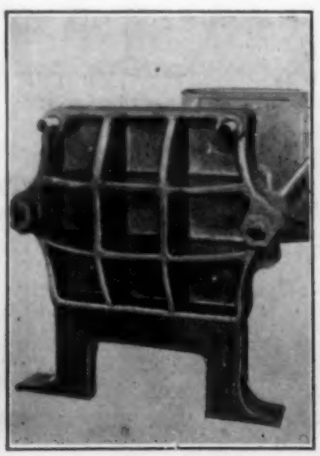

FIG. 7.

FIG. 10.

cult matter when handling the usual mixtures of solids and liquids to stop the filling operation at that point in which the adjacent cake walls are not yet touching each other. If all the conditions were precisely the same during each fill this system would be much more in use today than it actually is. The time allowed for filling is no criterion unless the conditions are always the

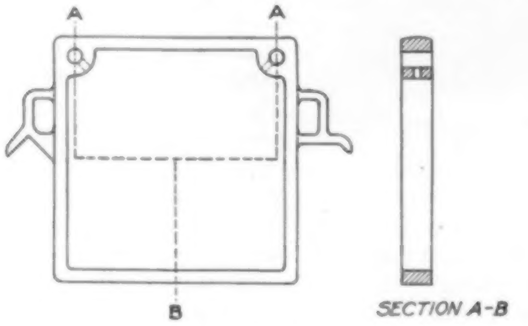


FIG. 5.

same. It is very seldom that the per cent of solids and their other physical properties are the same each fill. If they vary, then the filling time varies and the cake walls will either touch each other, causing poor washing, or they will be unnecessarily far apart decreasing the ca pacity of the filter-press. The pressure under which filtration is carried on is seldom exactly the same, due to different pump speeds, different operators, etc., making still another factor likely to cause trouble. The temperature will vary to a certain extent reducing the viscosity and changing the rate of deposition, making a third variable.

In order to secure the same capacity for solids as in the case of thorough washing where the chambers are allowed to fill completely, it is necessary that the chambers be made thicker or that the capacity for solids be decreased. It is a matter of common observation and of fact, that the cake on the walls of the filter-press chambers forms thicker at the bottom than at the top.

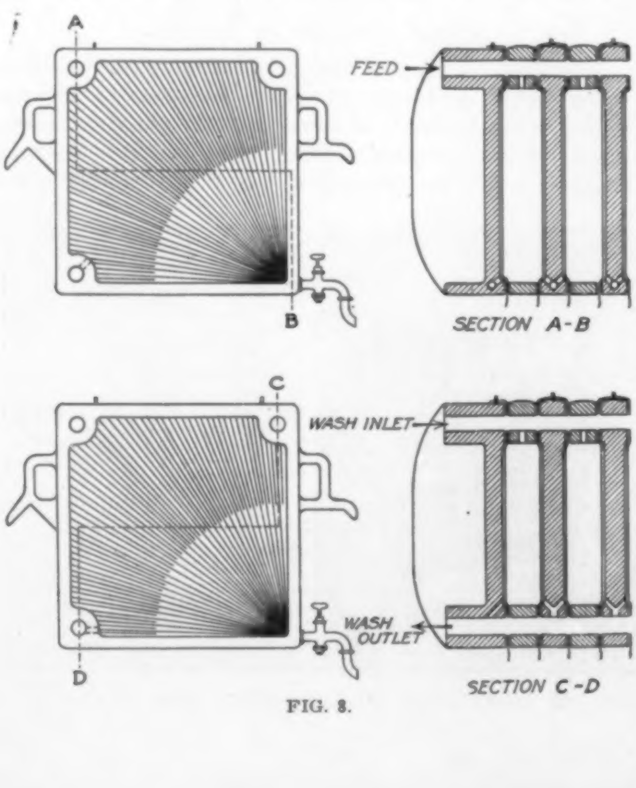


FIG. 8.

This is due to the effect of gravity on the solids which are being deposited. This means that if the wash-water is to reach all parts of the cake, it is necessary to stop the filling operation while the thicker bottom portions are still apart requiring a frame or chamber thicker than would be the case were the cake uniform in thickness. If this is done it can readily be seen that the upper or

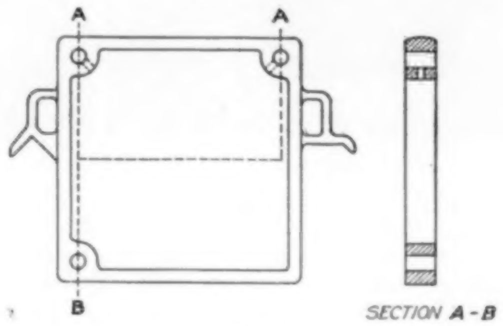


FIG. 9.

thinner part of the cake wall will be more thoroughly washed than the lower and thicker portion.

Simple washing is used most effectively in the case of finely divided substances which in a reasonable filling time form a very thin cake. In such a case, thorough washing is almost out of the question if the chambers are of much thickness, while by the use of simple washing all parts of the cake are very thoroughly washed. In finely divided substances the effect of gravity tending to make the cake walls of variable thickness is small, which is a point in favor of simple washing for this class of mixtures.

Batavia, Ill.

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**Potash Exploration.**—Secretary of the Interior Lane has approved working instructions and regulations under the potash leasing act of Oct. 2, 1917, a matter which has been given the most careful consideration, in view of the importance attached to this pioneer work in the development of a great national asset. The act is liberal in its terms, authorizing the exploration for and disposition of potash deposits generally in the public lands of the United States, undea system that provides for a preliminary permit to the holder for the exclusive privilege of searching for deposits of potash for a period of not exceeding two years. The acreage embraced within one permit is limited to $2560 acres, and the Secretary, upon a satisfactory showing that valuable deposits of potash have been found within the permit, is authorized to issue a patent to not exceed one-fourth of the amount covered by the permit, the remaining lands in the permit being subject to lease either by the permittee or others, after advertisement, competitive bidding, or such other methods as the Secretary may by general regulations adopt. To the end, therefore, that the liberal purposes of the act may find the fullest scope of operation, the instructions and regulations now approved, are broad in outline, simple in form, yet so directly addressed to the matter in hand that it is believed all applicants under the law will find but little difficulty in presenting their claims for consideration by the Department. Requests for copies of these instructions should be addressed to the Commissioner of the General Land Office, Washington, D. C.

# Annealing and Recrystallization of Cold-Rolled Aluminium Sheet

By ROBERT J. ANDERSON

THE present article gives the results of a series of tests made on the effects of heat at different temperatures on the softening of cold-rolled sheet aluminium; similar results, other than the late paper by Carpenter and Taverner,[1] so far as is known, have not hitherto appeared in the technical press. The common practice employed for annealing cold-rolled sheet aluminium is to heat the metal for a long period of time, say 18 to 30 hours at a temperature of approximately 375 deg. C. The annealing is carried out in large furnaces of the gas or oil-fired types, under pyrometric control, and upon completion of the anneal the metal is withdrawn and allowed to cool in air. Cold-rolled aluminium so heat-treated is very soft and pliable—the Shore scleroscope hardness being about 4 to 5. The aluminium referred to is first-grade metal analyzing 99 per cent Al and over, and with the impurities Si, Fe, Mn, and Cu in subordinate amounts. Experiments (not described in this article) have been made by the writer which showed that hard-worked, i.e., cold-rolled, aluminium can be softened to 4 or 5 Shore scleroscope hardness-number by short time exposures at temperatures near 375 deg. C. A description of the tests carried out on a variety of gages of cold-rolled aluminium sheet follows.

A chill-cast aluminium ingot was heated to 455 deg. C. in an ingot-heating furnace, and remained in the furnace approximately six hours before rolling. The analysis of this metal was as follows:

| | Per Cent. |
|---|---|
| Cu | 0.25 |
| Fe | 0.45 |
| Mn | trace |
| Si | 0.35 |
| Al, (by diff.) | 98.95 |

The ingot was broken down hot in a two-high breakdown mill to a slab whose dimensions were, 0.2291 in. x 40 in. x random; the reduction of the ingot, whose approximate dimensions were, 4 in. x 12 in. x 17 in., to the slab of the size given was accomplished by five or six passes in the mill. The slab so made was allowed to cool to room temperature; it was then slabbed cold to 0.1215-inch thick, and was then rolled to a succession of gages as follows: 10, 12, 14, 16, 18, 20, 22, 24, 26 and 28. The separate gages were all obtained from the same slab by rolling the slab to 10 gage, then shearing off a section, then rolling the remainder to 12 gage, shearing off a section, and so on until the range of gages mentioned was obtained. Sufficient metal of each gage was obtained to furnish samples for the annealing tests. In annealing, the time and temperature were varied over a wide range, as is shown in the accompanying tables, but the aim in general was to produce a softening to 4 or 5 Shore scleroscope number—this being considered maximum softness from the standpoint of practical mill operation. Annealed aluminium, however, at times may give a lower scleroscope reading.

[1]Carpenter, H. C. H. and Taverner, L., The Effects of Heat at Various Temperatures on the Rate of Softening of Cold-Rolled Aluminium Sheet; Paper before the Inst. of Metals (London), Fall, 1917; and in Engrg. (London), vol. 104, 1917, No. 8, p. 312.

### Relation of Hardness and Ductility

Hard-worked aluminium sheet will have a scleroscope hardness ranging from 13 to 15, and in the hard-worked condition the metal cannot be drawn into shapes in the draw press. In the annealed condition, the scleroscope hardness will be 4 to 5; semi-annealed or "half-hard" sheet aluminium has a scleroscope hardness of from 7 to 11, depending upon the annealing period or the number of passes through the rolls. Thus a "half-hard" sheet may be produced by a partial anneal upon a cold-rolled sheet, or by giving an annealed sheet a few passes through the rolls of a finishing mill. An annealed sheet whose scleroscope hardness is 4 to 5 may possess maximum ductility or very little depending upon the period of annealing and the temperature. For instance, if a given cold-rolled sheet be annealed for say 30 hours at 400 deg. C., its scleroscope hardness will be about 4, but it will be in a weakened condition and possess a relatively large grain size; on the other hand, if the same metal be annealed for 10 minutes at 400 deg. C., its scleroscope hardness will also be about 4, but it will be much stronger and have a smaller grain size than the first-mentioned sheet. For drawing, bending, and shaping operations on aluminium sheet, it is necessary that the metal have the maximum ductility which can occur together with a scleroscope hardness of 4 to 5.

### Annealing Experiments On Aluminium Sheet

In Table I, are given the results of tests made on the original hard sheets as they came from the mill. The ductility values were obtained with the Erichsen ductility testing machine for sheet metal, and hardness was taken with the Shore scleroscope. Percentages of reduction on the various gages of sheets were calculated according to formula, using 40 inches as the constant width, and starting from the 3-gage slab. Table II gives the percentages of reduction as calculated from the formula.

$$\frac{\text{Original area} - \text{final area}}{\text{original area}} \times 100 = \text{per cent reduction}$$

Annealings were made on all the different gages mentioned above, employing different times and temperatures, for the purpose of fixing the softening range of the metal for a given amount of deformation, i.e., percentage of reduction. Scleroscope hardness numbers were used to indicate softenings, and Erichsen tests were made when desirable. The results are given in Tables IV to XIV inclusive. There was a measurable

TABLE I. ERICHSEN AND SCLEROSCOPE VALUES FOR THE HARD SHEETS

| Mark | Sheet Gage | Scleroscope Hardness | Thickness in Millimeters | Indentation in Millimeters | Measured Thickness in In. by Micrometer |
|---|---|---|---|---|---|
| 1 | 3 | 5.0 | 5.96 | .... | 0.2291 |
| 2 | 8 | 12.5 | 3.11 | .... | 0.1215 |
| 3 | 10 | 14.0 | 2.58 | 10.01 | 0.1037 |
| 4 | 12 | 15.0 | 2.05 | 9.49 | 0.0841 |
| 5 | 14 | 15.0 | 1.70 | 8.24 | 0.0650 |
| 6 | 16 | 15.5 | 1.32 | 7.28 | 0.0512 |
| 7 | 18 | 15.0 | 1.02 | 6.58 | 0.0401 |
| 8 | 20 | 15.0 | 0.79 | 6.16 | 0.0321 |
| 9 | 22 | 15.0 | 0.68 | 5.92 | 0.0275 |
| 10 | 24 | 14.5 | 0.54 | 5.16 | 0.0220 |
| 11 | 26 | 15.0 | 0.40 | 4.57 | 0.0169 |
| 12 | 28 | 13.5 | 0.30 | 3.64 | 0.0128 |

NOTE.—The figures given represent the mean of closely agreeing determinations.

TABLE II. PERCENTAGES OF REDUCTION OF HARD SHEETS

| Mark | Sheet Gage | Measured Thickness in In. | Percentage Reduction |
|---|---|---|---|
| 1 | 3 | 0.2291 | ..... |
| 2 | 8 | 0.1215 | 47.00 |
| 3 | 10 | 0.1037 | 54.85 |
| 4 | 12 | 0.0841 | 63.30 |
| 5 | 14 | 0.0650 | 71.60 |
| 6 | 16 | 0.0512 | 77.70 |
| 7 | 18 | 0.0401 | 82.60 |
| 8 | 20 | 0.0321 | 86.00 |
| 9 | 22 | 0.0275 | 88.00 |
| 10 | 24 | 0.0220 | 90.50 |
| 11 | 26 | 0.0169 | 92.70 |
| 12 | 28 | 0.0128 | 94.50 |

NOTE.—There is some difference in the measured thickness of the sheets in inches compared to the measured thickness in millimeters (from the Erichsen tests) calculated to inches due to variation in the thicknesses of the sheets and the fact that the measurements were made at different points on the sheets, but these differences do not vitiate the results.

TABLE III. SHOWING VARIATIONS IN THICKNESSES OF SHEETS

| Mark | Sheet Gage | Measured Thickness in In. | Measured Thickness in Millimeters | Calculated In. from Measured Millimeters | Calculated Millimeters from Measured In. |
|---|---|---|---|---|---|
| 1 | 3 | 0.2291 | 5.96 | 0.2384 | 5.73 |
| 2 | 8 | 0.1215 | 3.11 | 0.1244 | 3.04 |
| 3 | 10 | 0.1037 | 2.58 | 0.1032 | 2.59 |
| 4 | 12 | 0.0841 | 2.05 | 0.0820 | 2.10 |
| 5 | 14 | 0.0650 | 1.70 | 0.0680 | 1.63 |
| 6 | 16 | 0.0512 | 1.32 | 0.0528 | 1.28 |
| 7 | 18 | 0.0401 | 1.02 | 0.0408 | 1.00 |
| 8 | 20 | 0.0321 | 0.79 | 0.0316 | 0.80 |
| 9 | 22 | 0.0275 | 0.68 | 0.0272 | 0.687 |
| 10 | 24 | 0.0220 | 0.54 | 0.0216 | 0.55 |
| 11 | 26 | 0.0169 | 0.40 | 0.0160 | 0.42 |
| 12 | 28 | 0.0128 | 0.30 | 0.0120 | 0.32 |

TABLE IV. EFFECTS OF ANNEALING 10-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 54.85

| Mark | Time in Minutes | Temperature Deg. C. | Scleroscope Hardness | Indentation in Millimeters | Appearance of Domes |
|---|---|---|---|---|---|
| 3M | 120 | 200 | 10.2 | ..... | ........... |
| 3A | 10 | 300 | 10.0 | ..... | ........... |
| 3B | 30 | 300 | 7.0 | 12.20 | ........... |
| 3C | 60 | 300 | 5.0 | 12.60 | Coarse |
| 3E | 30 | 350 | 5.0 | 12.54 | Medium |
| 3N | 5 | 400 | 10.6 | ..... | ........... |
| 3G | 10 | 400 | 5.0 | 12.12 | Coarse |
| 3H | 30 | 400 | 4.8 | 12.32 | Coarse |
| 3I | 60 | 400 | 4.5 | 11.75 | Coarse |
| 3J | 10 | 600 | 4.0 | 10.90 | Very coarse |

TABLE V. EFFECTS OF ANNEALING 12-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 63.30

| Mark | Time in Minutes | Temperature Deg. C. | Scleroscope Hardness | Indentation in Millimeters | Appearance of Domes |
|---|---|---|---|---|---|
| 4M | 120 | 200 | 11.6 | ..... | .......... |
| 4A | 10 | 300 | 10.6 | ..... | .......... |
| 4B | 30 | 300 | 7.1 | 10.97 | .......... |
| 4C | 60 | 300 | 4.9 | 11.70 | Coarse |
| 4K | 20 | 350 | 5.0 | 11.93 | Medium |
| 4E | 30 | 350 | 5.0 | 12.20 | Coarse |
| 4F | 60 | 350 | 5.0 | 11.70 | Coarse |
| 4N | 5 | 400 | 10.6 | ..... | .......... |
| 4G | 10 | 400 | 4.9 | 11.41 | Coarse |
| 4H | 30 | 400 | 5.0 | 11.27 | Coarse |
| 4I | 60 | 400 | 4.6 | 11.06 | Coarse |
| 4J | 10 | 600 | 4.4 | 10.51 | Coarse |

TABLE VI. EFFECTS OF ANNEALING 14-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 71.60

| Mark | Time in Minutes | Temperature Deg. C. | Scleroscope Hardness | Indentation in Millimeters | Appearance of Domes |
|---|---|---|---|---|---|
| 5M | 120 | 200 | 10.0 | ..... | .......... |
| 5A | 10 | 300 | 10.6 | ..... | .......... |
| 5B | 30 | 300 | 8.1 | 10.35 | .......... |
| 5C | 60 | 300 | 4.9 | 11.51 | Coarse |
| 5K | 20 | 350 | 5.0 | 10.90 | Medium |
| 5E | 30 | 350 | 5.0 | 10.84 | Coarse (?) |
| 5F | 60 | 350 | 5.0 | 10.77 | Coarse (?) |
| 5N | 5 | 400 | 12.5 | ..... | .......... |
| 5G | 10 | 400 | 5.0 | 10.68 | Coarse (?) |
| 5H | 30 | 400 | 4.9 | 10.60 | Coarse (?) |
| 5I | 60 | 400 | 4.7 | 10.32 | Coarse |
| 5J | 10 | 600 | 4.1 | 9.75 | Coarse |

TABLE VII. EFFECTS OF ANNEALING 16-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 77.70

| Mark | Time in Minutes | Temperature Deg. C. | Scleroscope Hardness | Indentation in Millimeters | Appearance of Domes |
|---|---|---|---|---|---|
| 6M | 120 | 200 | 10.7 | ..... | ...... |
| 6A | 10 | 300 | 11.0 | 8.83 | ...... |
| 6B | 30 | 300 | 8.1 | 9.21 | ...... |
| 6C | 60 | 300 | 5.4 | 10.75 | Medium |
| 6D | 10 | 350 | 8.9 | 8.90 | ...... |
| 6Y | 15 | 350 | 5.0 | 10.97 | Smooth |
| 6K | 20 | 350 | 5.0 | 10.21 | Medium |
| 6E | 30 | 350 | 4.9 | 10.70 | Medium |
| 6F | 60 | 350 | 4.5 | 9.76 | Medium |
| 6N | 5 | 400 | 13.4 | ..... | ...... |
| 6G | 10 | 400 | 5.0 | 9.68 | Coarse |
| 6H | 30 | 400 | 4.9 | 9.82 | Coarse |
| 6I | 60 | 400 | 4.8 | 9.68 | Coarse |
| 6J | 10 | 600 | 4.1 | 9.55 | Coarse |

TABLE VIII. EFFECTS OF ANNEALING 18-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 82.60

| Mark | Time in Minutes | Temperature Deg. C. | Scleroscope Hardness | Indentation in Millimeters | Appearance of Domes |
|---|---|---|---|---|---|
| 7M | 120 | 200 | 11.0 | ..... | ...... |
| 7A | 10 | 300 | 11.7 | 8.20 | ...... |
| 7B | 30 | 300 | 9.0 | 8.45 | ...... |
| 7C | 60 | 300 | 5.1 | 9.96 | Medium |
| 7D | 10 | 350 | 10.1 | 8.35 | ...... |
| 7K | 20 | 350 | 4.8 | 9.62 | Medium |
| 7E | 30 | 350 | 5.0 | 9.98 | Medium |
| 7F | 60 | 350 | 4.5 | 9.23 | Medium |
| 7N | 5 | 400 | 13.1 | ..... | ...... |
| 7G | 10 | 400 | 4.9 | 8.80 | Medium |
| 7H | 30 | 400 | 4.5 | 8.92 | Coarse |
| 7I | 60 | 400 | 4.1 | 9.02 | Coarse |
| 7J | 10 | 600 | 4.1 | 8.60 | Coarse |

variation in the thickness of the sheets at different points on their surfaces; and the measured thickness in inches by micrometer, the measured thicknesses in millimetres from the Erichsen test, the calculated inches to millimetres, and the calculated millimetres to inches are summarized in Table III. The annealings were carried out in a small laboratory electric furnace of the resistance type, and the temperatures given are accurate to ± 5 deg. C. The samples were cut from the various gages to a size of 3 in. x 10 in., thereby providing sufficient surface for three Erichsen tests and scleroscope hardness tests.

### Appearance of the Annealed Samples

Blisters began to be apparent on samples marked F, which were annealed for 60 minutes at 350 deg. C.; sheets marked G, annealed for 10 minutes at 400 deg. C. showed small blisters in all gages, as did those marked H, I, J and N. The matter of blistering is somewhat uncertain, and the writer has obtained such contradictory results on aluminium that he would not care to speak with certainty at the present writing. The results of the tests under discussion show that the metal blistered in all gages when heated to 400 deg. C. for even short times, and that at 350 deg. C. blistering starts after annealing for 60 minutes. Blisters are more or less dependent upon the original cast metal—the gas contained being a function of the temperature and speed of pouring, and also probably upon the melting practice. Thus, it has been found that certain sheets blister while others do not when annealed at the same temperature and for the same length of time.

TABLE IX. EFFECTS OF ANNEALING 20-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 86.00

| Mark | Time in Minutes | Temperature, Deg. C. | Scleroscope Hardness | Indentation in Millimeters | Appearance of Domes |
|---|---|---|---|---|---|
| 8M | 120 | 200 | 10.3 | ...... | ....... |
| 8A | 10 | 300 | 11.9 | 7.32 | ....... |
| 8O | 20 | 300 | 4.8 | 8.65 | Medium |
| 8B | 30 | 300 | 4.8 | 8.75 | Medium |
| 8L | 40 | 300 | 5.0 | 8.74 | Medium |
| 8C | 60 | 300 | 4.7 | 9.42 | Smooth |
| 8D | 10 | 350 | 10.0 | 7.40 | ....... |
| 8K | 15 | 350 | 4.6 | 8.60 | Medium |
| 8E | 30 | 350 | 5.0 | 8.95 | Smooth |
| 8F | 60 | 350 | 4.5 | 8.52 | Smooth |
| 8N | 5 | 400 | 5.0 | 9.20 | Smooth |
| 8G | 10 | 400 | 5.1 | 8.44 | Medium |
| 8H | 30 | 400 | 4.3 | 8.47 | Coarse |
| 8I | 60 | 400 | 4.5 | 8.45 | Coarse |
| 8J | 10 | 600 | 4.2 | 8.26 | Coarse |

TABLE X. EFFECTS OF ANNEALING 22-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 88.00

| Mark | Time in Minutes | Temperature, Deg. C. | Scleroscope Hardness | Indentation in Millimeters | Appearance of Domes |
|---|---|---|---|---|---|
| 9M | 120 | 200 | 10.4 | ...... | ....... |
| 9A | 10 | 300 | 12.0 | 7.04 | ....... |
| 9O | 20 | 300 | 6.0 | 8.25 | ....... |
| 9P | 25 | 300 | 4.9 | 8.35 | Smooth |
| 9B | 30 | 300 | 5.0 | 8.40 | ....... |
| 9L | 40 | 300 | 4.9 | 8.35 | Smooth |
| 9C | 60 | 300 | 4.6 | 8.60 | Smooth |
| 9D | 10 | 350 | 5.0 | 8.75 | ....... |
| 9K | 15 | 350 | 4.6 | 8.30 | Smooth |
| 9E | 30 | 350 | 4.8 | 8.39 | Smooth |
| 9F | 60 | 350 | 4.6 | 8.24 | Smooth |
| 9N | 5 | 400 | 9.0 | 7.12 | ....... |
| 9G | 10 | 400 | 4.5 | 8.28 | Medium |
| 9H | 30 | 400 | 4.3 | 8.12 | Coarse |
| 9I | 60 | 400 | 4.1 | 8.25 | Coarse |
| 9J | 10 | 600 | 4.0 | 7.95 | Coarse |

TABLE XI. EFFECTS OF ANNEALING 24-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 90.50

| Mark | Time in Minutes | Temperature Deg. C. | Scleroscope Hardness | Indentation in Millimeters | Appearance of Domes |
|---|---|---|---|---|---|
| 10M | 120 | 200 | 10.4 | ...... | ....... |
| 10A | 10 | 300 | 10.5 | 6.72 | ....... |
| 10O | 20 | 300 | 4.7 | 8.25 | Smooth |
| 10B | 30 | 300 | 4.6 | 8.15 | Smooth |
| 10L | 40 | 300 | 4.8 | 8.00 | Smooth |
| 10C | 60 | 300 | 4.7 | 8.07 | Medium |
| 10D | 10 | 350 | 8.1 | 7.01 | ....... |
| 10K | 15 | 350 | 4.7 | 7.84 | Smooth |
| 10E | 30 | 350 | 4.4 | 7.95 | Smooth |
| 10F | 60 | 350 | 4.5 | 7.95 | Smooth |
| 10N | 5 | 400 | 7.0 | 6.79 | ....... |
| 10G | 10 | 400 | 4.6 | 7.74 | Smooth |
| 10H | 30 | 400 | 4.2 | 8.05 | Medium |
| 10I | 60 | 400 | 4.2 | 7.98 | Medium |
| 10J | 10 | 600 | 4.2 | 7.65 | Coarse |

## Other Annealing Experiments

A set of samples of all gages were annealed in a large mill furnace at 370 deg. C. for 24 hours, and the results of the tests are summarized in Table XIV. All the fractured domes of the Erichsen tests were

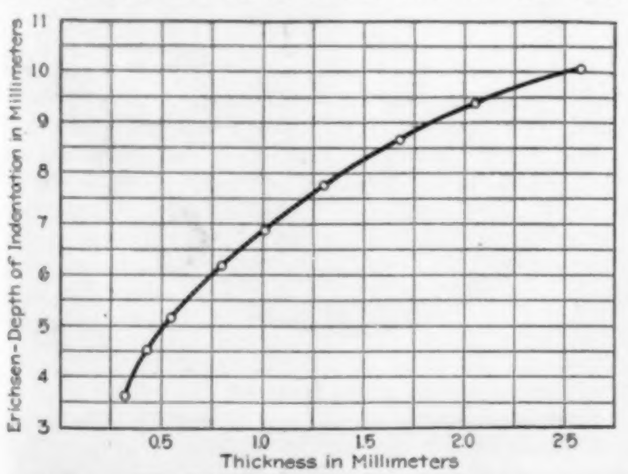


FIG. 1. THICKNESS—IDENTATION CURVE FOR COLD-ROLLED ALUMINIUM SHEET

TABLE XII. EFFECTS OF ANNEALING 26-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 92.70

| Mark | Time in Minutes | Temperature Deg. C. | Scleroscope Hardness | Indentation in Millimeters | Appearance of Domes |
|---|---|---|---|---|---|
| 11M | 120 | 200 | 10.0 | ..... | ....... |
| 11A | 10 | 300 | 9.7 | 6.20 | Smooth |
| 11O | 20 | 300 | 4.5 | 7.50 | Smooth |
| 11B | 30 | 300 | 4.6 | 7.68 | Smooth |
| 11L | 40 | 300 | 5.0 | 7.30(?) | Smooth |
| 11C | 60 | 300 | 4.6 | 7.52 | Smooth |
| 11D | 10 | 350 | 7.7 | 6.43 | ....... |
| 11K | 15 | 350 | 4.5 | 7.51 | Smooth |
| 11E | 30 | 350 | 4.5 | 7.70 | Smooth |
| 11F | 60 | 350 | 4.2 | 7.72 | Smooth |
| 11N | 5 | 400 | 5.0 | 7.40 | Smooth |
| 11G | 10 | 400 | 4.6 | 7.43 | Smooth |
| 11H | 30 | 400 | 4.0 | 7.55 | Smooth |
| 11I | 60 | 400 | 4.1 | 7.54 | Medium |
| 11J | 10 | 600 | 4.1 | 7.27 | Coarse |

TABLE XIII. EFFECTS OF ANNEALING 28-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 94.50

| Mark | Time in Minutes | Temperature Deg. C. | Scleroscope Hardness | Indentation in Millimeters | Appearance of Domes |
|---|---|---|---|---|---|
| 12M | 120 | 200 | 10.1 | .... | ....... |
| 12A | 10 | 300 | 9.9 | 5.30 | ....... |
| 12O | 20 | 300 | 4.6 | 7.31 | Smooth |
| 12B | 30 | 300 | 4.5 | 7.52 | Smooth |
| 12L | 40 | 300 | 4.9 | 7.15 | Smooth |
| 12C | 60 | 300 | 4.8 | 7.35 | Smooth |
| 12D | 10 | 350 | 7.1 | 6.90 | ....... |
| 12K | 15 | 350 | 4.1 | 7.35 | Smooth |
| 12E | 30 | 350 | 4.8 | 7.33 | Smooth |
| 12F | 60 | 350 | 4.3 | 7.15 | Smooth |
| 12N | 5 | 400 | 6.0 | 6.95 | ....... |
| 12G | 10 | 400 | 4.2 | 7.16 | Smooth |
| 12H | 30 | 400 | 4.3 | 7.40 | Smooth |
| 12I | 60 | 400 | 4.2 | 7.42 | Smooth |
| 12J | 10 | 600 | 4.0 | 6.96 | Coarse |

extremely coarse, indicative of large grain size and poor drawing quality. Long-time annealings for cold-rolled aluminium sheet are very harmful and confer undesirable properties upon the metal. A number of re-annealings were made upon 18-gage cold-rolled sheet, and the results of the physical tests were comparable to those in Table VIII.

## Curve Plots

In the case of cold-rolled aluminium sheet of a given gage, it is possible to make curve plots showing the time required for softening the metal to 4-5 Shore scleroscope number when employing various temperatures. The time for a given temperature depends upon the percentage of reduction of the cold-rolled sheet, and to a less extent upon its thickness. Fig. 1 is a thickness-indentation curve for cold-rolled aluminium sheet; indentation, as will be noted, varies with the thickness of the metal—heavier gages of sheets giving deeper indentations, other things being equal. Fig. 2 is a curve plotted from a set of composite results from the various tables (the figures were taken so that the Shore scleroscope number was 5 or below, and the

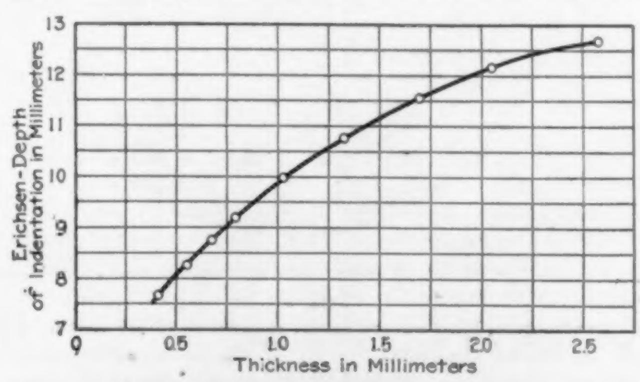


FIG. 2. THICKNESS—IDENTATION CURVE FOR ANNEALED ALUMINIUM SHEET

depth of indentation the highest for the shortest times and lowest temperatures, together with a smooth dome on the ruptured Erichsen test piece). The figures used were those in Table XV, and the curve shown in Fig. 2 may be taken as a correct thickness-indentation curve for annealed aluminium sheets for drawing purposes.

### Microscopic Examination

Microsections were procured from most of the annealed samples, and the internal structure of the metal was examined for general characteristics, recrystallization, etc. The photomicrographs in Figs. 3 to 6 inclusive illustrate the effects of annealing 12-gage cold-rolled sheet which had been reduced 63.30 per cent in the cold. Fig. 3 is a photomicrograph of the original cold-rolled sheet; there is no evidence of crystallinity; grain boundaries cannot be discerned, and the metal is evidently mostly amorphous. The degree of deformation employed was large, and the structure of the metal is as would be expected. Fig. 4 illustrates the appearance of this metal after annealing for 60 minutes at 350 deg. C.; recrystallization has commenced but is far from complete. However, when annealed in the manner just mentioned, the metal was "dead" soft, even though recrystallization had not proceded very far. Fig. 5 shows the same metal after annealing at 400 deg. C. for 60 minutes, and recrystallization is still far from complete. Fig. 6 is the same metal after annealing at 600 deg. C. for 10 minutes: it will be observed from inspection of the photomicrographs that with a much shorter time but at a more elevated temperature that recrystallization has proceded further in Fig. 6 than

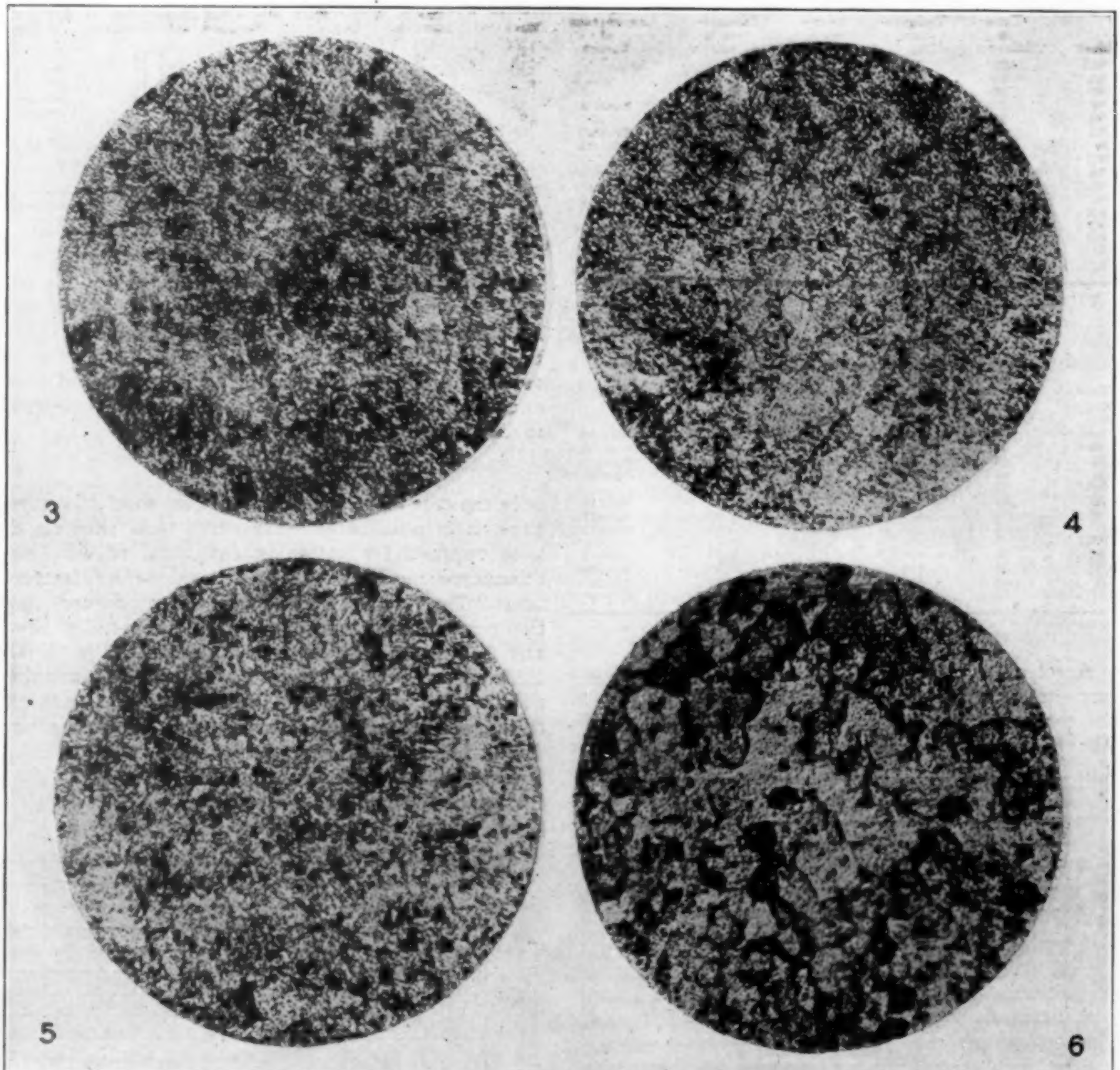


FIG. 3

Twelve-gage, hard-worked sheet; reduced 63.30 per cent in the cold; etched with HF; x 100 diameters.

FIG. 4

Twelve-gage sheet, after annealing, at 350 deg. Cent. for 60 minutes; etched with HF; x 100 diameters.

FIG. 5

Twelve-gage sheet, after annealing at 400 deg. Cent. for 60 minutes, etched with HF; x 100 diameters.

FIG. 6

Twelve-gage sheet, after annealing at 600 deg. Cent. for 10 minutes; etched with HF; x 100 diameters.

TABLE XIV. EFFECTS OF ANNEALING VARIOUS GAGES OF COLD-ROLLED ALUMINIUM SHEETS FOR 24 HOURS AT 370 DEG. C.

| Mark | Scleroscope Hardness | Indentation in Millimeters | Appearance of Domes |
|---|---|---|---|
| 3X | 4.9 | 12.64 | Coarse |
| 4X | 5.0 | 11.56 | Coarse |
| 5X | 4.9 | 10.82 | Coarse |
| 6X | 5.0 | 9.79 | Coarse |
| 7X | 4.9 | 9.55 | Coarse |
| 8X | 4.6 | 8.91 | Coarse |
| 9X | 4.7 | 8.56 | Coarse |
| 10X | 4.7 | 8.12 | Coarse |
| 11X | 4.5 | 8.00 | Coarse |
| 12X | 4.8 | 7.52 | Coarse |

TABLE XV. DATA USED FOR THICKNESS-INDENTATION CURVE IN FIG. 2

| Mark | Gage | Time in Minutes | Temperature Deg. C. | Scleroscope Hardness | Thickness Millimeters | Indentation Millimeters |
|---|---|---|---|---|---|---|
| 3C | 10 | 60 | 300 | 5.0 | 2.58 | 12.60 |
| 4E | 12 | 30 | 350 | 5.0 | 2.05 | 12.20 |
| 5C | 14 | 60 | 300 | 4.9 | 1.70 | 11.51 |
| 6Y | 16 | 15 | 350 | 5.0 | 1.32 | 10.97 |
| 7E | 18 | 30 | 350 | 5.0 | 1.02 | 9.98 |
| 8E | 20 | 30 | 350 | 5.0 | 0.79 | 8.95 |
| 9D | 22 | 10 | 350 | 5.0 | 0.68 | 8.75 |
| 10O | 24 | 20 | 300 | 4.7 | 0.54 | 8.25 |
| 11E | 26 | 30 | 350 | 4.5 | 0.40 | 7.70 |
| 12B | 28 | 30 | 300 | 4.5 | 0.30 | 7.52 |

TABLE XVI. EFFECT OF DEFORMATION ON TIME OF RECRYSTALLIZATION

| Mark | Gage | Per Cent Deformation | Microscopic Examination |
|---|---|---|---|
| 3E | 10 | 54.85 | Not recrystallized |
| 4E | 12 | 63.30 | Not recrystallized |
| 5E | 14 | 71.60 | Not recrystallized |
| 6E | 16 | 77.70 | Recrystallization commenced |
| 7E | 18 | 82.60 | Recrystallization commenced |

NOTE.—Samples marked E were all annealed for 30 minutes at 350 deg. Cent.

in Figs. 4 and 5. Recrystallization is still incomplete in Fig. 6. These photomicrographs show, and microscopic examination has confirmed the fact, that cold-rolled aluminium sheet recrystallizes but slowly on annealing. Microscopic examination of other gages gave results in conformity with what was expected, and in general recrystallization commences at lower temperatures and with shorter times with increasing deformation. This may be instanced by the summary of the microscopy of annealed sheets of various gages in Table XVI.

As to the mechanical softening of cold-rolled aluminium sheet from 15 to 4 scleroscope-number without concomitant recrystallization: In the present somewhat uncertain state of our knowledge, it appears that there may be a complete mechanical softening, which occurs and leaves the strained structure of the metal the same so far as the microscopic examination is able to show. With prolonged annealing, this may be followed by recrystallization and grain growth, while the softness remains the same or nearly so. The mechanical softening brought about by heating strained metal, such as cold-rolled aluminium sheet, is probably due to an undescribed change in the amorphous metal enclosing the remaining grain fragments resulting from extreme deformation in the cold, or to a continued absorption of the amorphous metal by these fragments, or possibly both. These changes in the condition of the amorphous metal are not sufficient to bring about visible changes in the etching characteristics of the internal structure.

## Summary

The results of the tests made on the annealing of cold-rolled aluminium sheet show, and their practical application in the mill has proved, that there is no necessity for the present general practice of annealing aluminium. The effect of long-time annealings, such as are common in present practice, where sheets are exposed for say 24 hours at 375 deg. C., is to cause an undue coarsening and weakening of the metal which is evidenced by the coarse domes in the Erichsen test. In Table XIV, it will be noticed that all the samples gave very coarse domes. Fabricating blanks so annealed and which have undergone deep draws in the draw press also show the same coarse appearance at the edges of the drawn shapes, and this can be traced only to the long annealing period. The Erichsen apparatus in furnishing data as to the ductility of metal sheets, and their workability in the draw press provides a means of testing which is valuable.

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# The Use of Wood in Chemical Apparatus

**Classified Results of an Inquiry by the Forest Products Laboratory, Regarding Practical Experience With Wooden Containers Used in Various Chemical and Metallurgical Industries**

BY A. W. SCHORGER

THE great expansion in the chemical and metallurgical industries during the past three years has resulted in increased interest in the use of wood for apparatus, particularly apparatus for use with acid solutions. In some cases manufacturers have constructed wooden apparatus because they could not obtain metal; but in many cases wood has a distinct advantage over all other materials when used in the presence of acids. The receipt by the Forest Products Laboratory of numerous inquiries about the suitability of various species of woods for use in such apparatus led to an attempt to collect such information as might be available on the subject.

Laboratory experiments, while possessing some value, were considered inadvisable since years would have been required to complete the tests; also it would have been impossible even to approximate certain commercial conditions. Accordingly, a large number of letters were sent out to various manufacturers and users of wooden apparatus asking what their experience had been, especially in regard to the use of wood with acid solutions. The numbered paragraphs of this paper embody a summary of the replies received. No responsibility is assumed for their accuracy.

It is interesting to note the geographical influence upon the replies, preference generally being given to a wood growing in the region in which it was used. In the North, Central and New England States white pine and Norway pine were used most; in the West, redwood, and Douglas fir; and in the remaining territory, longleaf pine and cypress.

### EFFECT OF INORGANIC ACIDS ON WOOD

Wood is readily attacked by most of the inorganic acids. A 40 per cent solution of hydrochloric acid and concentrated sulphuric acid dissolves cellulose readily. More dilute acids attack the lignin and have slight action on the cellulose. In fact numerous attempts have been made to manufacture paper pulp by removing the incrusting materials with acids. For this purpose Barne and Blondel[1] used nitric acid; Orioli[2] using 40 per cent of a mixture of 20 per cent $HNO_3$ and 80 per cent HCl, obtained 50 per cent of long, strong fiber from 100 parts of wood; Lifschütz[3] employed a cold mixture of dilute nitric and sulphuric acids (3:1) and obtained 95 per cent of fiber. The solution was reused until the nitric acid was exhausted, leaving a solution containing $H_2SO_4$ and saturated with oxalic acid. Highly concentrated mixtures of nitric and sulphuric acid nitrate the wood.[4] Even very dilute solutions of hydrochloric acid or sulphuric acid contained in wood char it when it is dried at a temperature of 100 deg. C. The main action of acids on wood is hydrolytic. The lignin is separated from the cellulose fibers, the wood gradually disintegrating.

[1]Dingler's Polyt. J. 164 (1862) 464; 172 (1869) 238.
[2]Prakt. Handbuch der Papierfabr. 42 (1896) 163-32.
[3]German Patent 60, 233.
[4]Lifschütz, Ber. 24 (1891) 1186.

### PICKLING TANKS

1. A Chicago firm using hydrochloric acid and sulphuric acid at room temperature in its galvanizing department preferred Norway pine, but owing to inability to obtain suitable lengths was using yellow pine. The tank, using sulphuric acid of 15 to 16 deg. Bé and steam heated to a temperature of 82 to 99 deg. C., was made from longleaf yellow pine.

2. Wooden vats 15 to 40 feet in circumference are made of common pine, native of Massachusetts (probably white pine). This material requires less attention and shows a longer life than long leaf pine, cypress, or spruce. All of these woods have been thoroughly tried out. Absolutely dry cypress gave a slightly longer life than any of the others, but it was found commercially impractical to obtain thoroughly dry lumber. The sulphuric acid solution varies in strength from 3.5 to 8 per cent and the temperature ranges from 74 to 98 deg. C. The life of the tanks varies from one to two and one-half years, depending upon the size of the tank and the nature of the service, the smaller tanks lasting longest.

3. We use dilute sulphuric and hydrochloric acid at a temperature of about 65 deg. C. in our galvanizing plant. Both white pine and cypress have been used. The tanks fail by wearing off at the top and at the joints. The acid seems to eat away the material that holds the fibers together. Pine tanks last seven years and cypress from eight to nine. They are used only ten hours daily.

4. The hydrochloric acid is used undiluted and the sulphuric acid in about a 2 per cent solution, the former being generally used at a temperature of 21 deg. C. but has been used up to 65 deg. C.; the sulphuric acid is used at 65 deg. C. The tanks for these acids have been made of cypress, white pine, fir or oak, chiefly the first two; and it is our experience that as far as the wood is concerned its chief asset was in its natural advantages as a tank lumber, i. e., for holding water or any liquid, and in its ability to stand hard usage, as thousands of tons of steel are passed through the tanks in the shape of angles, etc. In being lowered and raised in and out of the tanks the steel causes considerable chafing and wear. Tanks which have now been in use six years show no appreciable change in the strength of the fibers $\frac{1}{16}$ to $\frac{1}{4}$-in. beneath the surface and resist the insertion of a knife blade the same as new wood. The breaking away of a splinter from the planks appears to be almost as difficult as with new wood.

5. For ordinary tanks for pickling steel products we always use cypress, which we understand from users of our tanks is very durable so long as the contents are not stronger than a 5 per cent solution.

6. We use hydrochloric and sulphuric acids at a temperature of 70 to 80 deg. C. We have had best success with cypress wood. The life of the tanks in our galvanizing department is about two years. The acid makes the wood spongy, and in about two years' time the solution begins to ooze through the staves so badly that the tank must be abandoned. The wear and tear upon our tanks is rather severe from the fact that we are galvanizing heavy parts and heavy bundles of small parts.

7. We use cypress with the best results for galvanizing tanks.

### Storage Tanks for Hydrochloric Acid

1. The hydrochloric acid is stored in a double-walled tank, the inner being made from "Louisiana red gulf *cypress*" and the outer tank of "special heart grade" *longleaf yellow pine*. The space between the tanks is filled with highly refined pitch-tar, which remains in a plastic condition. The inside tanks are sometimes painted with two or three coats of a mixture of rosin and pitch, and before assembling each stave is dipped in a hot tar solution.

2. Our experience—that is to say, the reports of our customers—has been that the best material for muriatic acid is either *longleaf pine* or Washington *fir*.

3. In the manufacture of muriatic acid, storage tanks were made of California *redwood*, and the acid was also shipped in tank cars made of the same wood.

The wood was prepared by first boiling tar until all the volatile products at the boiling point of the tar were distilled off, and then the clear redwood was immersed in this and boiled for about half an hour. The staves were then used to make up the tanks. The muriatic acid was maintained at atmospheric temperature and no heating was carried on in the tanks. To the writer's knowledge tanks made up in this manner lasted twenty years.

4. You can make wooden tanks and coat them with a mixture of asphaltum and some wood tar and they will stand quite a long time. We have some wooden tanks so built that we have been using for quite a number of years for transporting and storing muriatic acid. However, there is no wood that we know of that will stand for any length of time, either treated or not, the effects of either nitric or sulphuric acids.

5. We are manufacturers of sulphuric, muriatic, and hydrofluoric acids; the most serious trouble encountered is that of concentrating our acids to the commercial specific gravity. The fumes from the latter acids are weak, warm and penetrating. The best grade of wood which we have found to answer our purpose is white pine. We have also used some cypress with fairly good success; nevertheless we consider white pine the best for our purpose and for all the acids produced at this plant at various temperatures and gravities.

6. Hydrochloric acid scarcely attacks wood, especially if the latter is soaked in paraffin wax.

### Apparatus for Use with Acetic Acid

1. We use a great many wooden tanks in connection with our acetic acid operations. We have used redwood, cedar, and cypress tanks. The cypress are the most satisfactory. We also use wooden pipe lines, and all of these are made from spruce. They are only fairly satisfactory, however.

2. Wooden tanks are used in the manufacture of the vinegar and in its transportation. In both cases fir and cypress are used and with careful treatment they last a great many years. The acid seems to preserve the wood.

3. Acetic acid and vinegar are usually handled in fir tanks.

4. The writer has had experience in the use of wood in the manufacture of acetic acid. Ordinary white pine tanks were used to store the various strengths of acetic acid. Acetic acid was also shipped in second-hand whiskey barrels and we noticed no effect of the acid on the wood.

We also performed concentration and purification of acetic acid in a wooden tower made of clear *white pine*. This tower showed no effects of the acid.

5. We use wooden tanks made of cypress and pine in the manufacture of vinegar, the acetic acid content of which never exceeds 11 per cent.

6. Douglas fir is used almost exclusively by vinegar plants.

7. During the past few years we have had occasion to make smoke condensers for a certain company. The material must resist the action of acetic acid. After a good many years of experience they have settled on Norway pine as the proper material. They have tried Western fir and condemn it absolutely.

8. We have used wooden tanks as containers for pyroligneous acid, and with good results. These tanks are made of pine, and we have some still in good condition that have been in constant use for the last fifteen years.

9. A great many cypress tanks are used in the generation of vinegar and acetic acid and for holding vinegar.

### Separators for Storage Batteries

Wood is used extensively for separators in lead storage batteries containing sulphuric acid of from 1.2 to 1.4 specific gravity.

The wood must be given a preliminary treatment; for when it is used in the natural state substances very injurious to the lead plates are formed in presence of the sulphuric acid. Acetic acid is generally considered to be one of the most undesirable substances produced, but according to Skinner[5] a small quantity of acetic acid is beneficial rather than harmful to the negative plates. He finds that "white pine, Douglas fir, and the common species of cedar" are especially desirable for separators. In Skinner's patent, the woods, before use, are steamed under pressure for about 12 hours or boiled at atmospheric pressure for from 24 to 48 hours. The swelling and softening thus produced lower the internal resistance of the separators. In previous patents the separators were first treated with a 25 per cent solution of sodium bisulphite[6] at a temperature of 100 to 175 deg. C.; or with a 15 per cent solution of sodium sulphite[7] at 100 deg. C. for one hour. These solutions remove a portion of the lignin, and their use is founded on well-known methods of manufacturing paper pulp.

Morrison[8] treats the separators with melted paraffin. Heap[9] employs an alcoholic solution of caustic potash,

[5]U. S. Patent 1,130,640 (1915)
[6]Skinner, U. S. Patent 1,052,851 (1913)
[7]Skinner, U. S. Patent 1,098,357 (1914)
[8]U. S. Patent 1,058,779 (1913)
[9]U. S. Patent 1,051,580-2 (1913)

in which the separators are treated for four hours at 140 deg. C. and at a pressure of 100 pounds. Marino[10] steams the separators for 15 minutes at 120 deg. C. and then subjects them to oxidation by immersion in a 20 per cent solution of hydrogen peroxide for about 3 hours. The separators are finally steamed again for ten minutes at a temperature of about 110 deg. C. The method of Dodge[11] for preparing the separators for use consists in soaking them successively in dilute sulphuric acid and caustic potash. Whitehead and Marino[12] first submit the wood to an ammoniacal copper solution and then to a bath of ammonia sp. gr. 0.88. The separators are then treated successively with water, nitric acid, and sulphurous acid, and finally with alcohol, caustic potash, and ethyl acetate in various proportions.

Among the woods considered as having special value for storage batteries are yellow pine[13], cypress *(Taxodium distichum)*, and redwood *(Sequoia sempervirens)*[14]. Cypress is also considered to be least affected by alkaline solutions.[15]

Lyndon[16] states that for large size station storage batteries heavy wooden tanks lined with lead are universally used. These should be made of sound oak, pine, or teakwood thoroughly dried and boiled in paraffin or its equivalent, so that the pores may be completely filled. "Resinous wood such as pine has proved to be the most satisfactory and durable." This author also states that basswood is invariably used for the separators. At the present time basswood is being used to only a limited extent, preference being given to cypress, redwood, Douglas fir, and Port Orford cedar.

### Tanks for Saponification of Fats

1. Several of our customers using our tanks in the process of recovering glycerine from soap fats specify 4-inch genuine Louisiana red cypress for the bottoms and staves, and extra heavy hooping. This, we understand, is not only due to certain acids used in this process, but also because the fat contents of the tank are boiled.

2. Our experience is practically limited to the use of wooden tanks in contact with a solution of sulphuric acid containing also sulphonic acids, at a concentration of 1 to 2 per cent for each component at a boiling temperature, in the operation of the Twitchell process for fat splitting. We use for this purpose Louisiana cypress.

Tanks in continuous use with the Twitchell process, if properly constructed, have a life of at least ten years. The inner layer becomes charred in appearance and we therefore use staves not less than three inches thick; the charring will not penetrate more than about $\frac{3}{4}$-inch. We have recently taken down a tank which has been used about fifteen years and find the inside of the staves charred as described above, while the remainder of the wood still remains in serviceable condition. (A portion of a stave sent to this laboratory proved to be dense, resinous longleaf pine.)

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[10] U. S. Patent 1,023,948 (1912)
[11] U. S. Patent 1,000,330 (1911)
[12] English Patent 20,143 (1905)
[13] Waldron, U. S. Patent, 463,879 (1891)
[14] Taylor, U. S. Patent, 1,012,751 (1911)
[15] Edison, U. S. Patent 754,858 (1904)
[16] "Storage Battery Engineering" (1911)

### Miscellaneous

1. The slight experience that we have had leads us to believe that cypress wood stands the action of all kinds of acids the best.

2. We have had so many complain of Washington fir that we have given up the manufacture of Washington fir tanks for acid of any kind unless specifically ordered. We consider yellow pine in general better than white pine.

3. We make the tanks principally from Louisiana red gulf cypress. In some cases longleaf pine is requested. We have also made some from Oregon fir. It appears that for certain chemicals longleaf pellow pine is specified by the users on account of the acid resisting qualifies of the pitch contained in the pine.

4. Longleaf pine seems to be most popular with the paper mills for sulphite solution, while cypress is universally demanded by the chemical companies.

5. We have tanks constantly in use exposed to dilute acetic, muriatic, sulphuric and chromic acids, and, in our opinion, nitric acid could also be used if sufficiently dilute. These acids are in various dilute solutions, say about 5 to 10 per cent, and above the solution they exist in the form of steam. The temperature rises as high as 100 deg. C.

The best wood to use for these tanks is longleaf yellow pine as it seems to last longer than any other kind. Many of the dye-stuff and chemical manufacturers use wooden tanks generally, and a good many use acids in them. In time the acid softens the wood and causes the tanks to leak no matter how often they are tightened up. Some of our tanks have lasted as long as four years and given good service.

6. We have recently made some acid towers for one of the paper companies and they find Western fir satisfactory. This material comes in contact with sulphurous acid principally.

7. Wood filter-presses are almost invariably used for filtering acid mixtures. Considerable difference of opinion exists as to what woods are best suited for the filtering of various acids. We usually use paraffined hard maple. The plates are sometimes made of longleaf pine, oak, ash, and cypress.

8. We use an acid solution in our plant which is almost saturated with sodium sulphate and chloride. The acids present are sulphuric, sulphurous, and hydrochloric, the maximum strength being about 1 per cent. The temperature of the solution is about 30 deg. C., although in the leaching tanks 100 deg. is approached at times. We are using both Douglas fir and redwood. After three years of service both kinds of wood appear in good condition.

We also handle our waster smoke after passing through a scrubbing tower, through an exhaust fan built of wood. Under these smoke conditions the Douglas fir loses its strength and become black and soft. When there are no particular strains to resist, it lasts for several years. We are trying out redwood for this purpose and expect better results.

9. Fir will withstand the action of 18 per cent hydrochloric acid for about six months; North Carolina yellow pine will withstand the action of weak sulphuric acid up to about 5 per cent for one year, but even before that time, in case the acid is agitated, the wood begins to shred.

10. Most of our experience has been in handling hydrofluosilicic acid ($H_2SiF_6$) mostly at strengths of 10 per cent and 35 per cent. The former solution is always handled at 100 deg. F. and the latter at atmospheric temperature. This acid has been used in wooden tanks made of fir, yellow pine, and cypress. We have also packed the 35 per cent acid in oak barrels. The wooden tanks are always lined with asphalt and the barrels with paraffin. None of these woods will stand the acid for any length of time unless the wood is coated with some lining. Whenever the acid is in contact with wood the alternate fibers are dissolved away, leaving the wood in a condition very much resembling a pad of paper.

Pipe made of tamarack was used for carrying 12 per cent hydrofluosilicic acid at a temperature of 100 deg. F. After three years' service it was still in good condition.

11. One of our lines conveys a solution containing 4 per cent or 5 per cent sulphuric acid. The pipe (tamarack) seems to remain as sound as ever.

12. While cypress gives better results for hot acids, yellow pine is superior to it for cold or warm acids.

13. Cypress tanks are used almost exclusively for acids and chemicals, and for hot liquids, as nothing else will give as lasting service.

14. Tamarack is a very satisfactory wood for silos, as it resists decay and the effects of the acids formed by the silage.

15. The pipe is made of white pine, selected free of all sap and other imperfections. We have furnished it extensively to acid factories, chemical works, vinegar and cider plants, for conveying vinegar, cider, and various acid liquors, such as dilute sulphuric, nitric, muriatic, and acetic acids.

16. Pipes made of white pine and tamarack are used for handling mine waters and dilute acids.

17. The lining of flues and hoods over acid vats (HCl and $H_2SO_4$) appears to last longer when made of spruce than of native pine (Massachusetts). This is probably due to the fact that the spruce is harder than the pine and does not disintegrate so rapidly around the nails.

18. We use cold HCl 3 deg. Bé, and boiling hot $H_2SO_4$ 2 deg. Bé, and prefer old growth Oregon fir (Douglas fir).

Boehringer and Sons[19] use chlorinated compounds for coating and impregnating wood. It is claimed that substances possessing to a high degree chemical inertness towards acids, halogens, etc., are obtained when animal and vegetable oils, fats, and waxes, are chlorinated under such conditions as will insure the introduction of at least 30 per cent chlorine. Chlorinated products from mineral oils show a high degree of resistance towards the action of alkalis and acids.

Forest Products Laboratory, Forest Service,
United States Department of Agriculture.

## American Iron and Steel Institute

The fourteenth general meeting of the American Iron and Steel Institute will be held at the Waldorf-Astoria, New York, Friday and Saturday, May 24 and 25. A business meeting for the election of seven directors to serve for the next three years was held Monday, May 6, at the office of the Institute, 61 Broadway.

[19]French Patent 433,415 (1911).

# Defects in Industrial Rubber Goods

## A Glossary of Defects with Suggestions as to Cause and Prevention

By Frederic Dannerth

OCCASIONAL claims for damages because of defects in finished products is an experience common to most manufacturing industries. This is obviously due to the fact that no product is perfect in the literal sense of the word. Hence *perfection* is only a relative conception, and the various tests applied to finished products are nothing more than methods used for determining how near perfect, the product is.

Defects may be due to the raw materials, to the processes of manufacture, or to the conditions under which the finished goods were shipped and stored. The fact that the goods were defective when they came into the possession of the consumer, is usually the form in which the complaint reaches the sales manager. So far as the writer is aware no attempt has been made to record concisely any of these defects in rubber goods, and it would seem that such an enumeration is especially desirable at a time when buyer and seller are making an honest attempt at understanding each other. A defect may be defined as "a property which impairs the value of the product, and renders it less fit for the purpose for which it was intended." If a perfect product be called *normal* the defective product may well be called *abnormal*, just as the physician applies these terms to persons who are sick or deformed. Following the analogy, it is possible to determine the cause, characteristics and remedy for each defect, and discover means for preventing its occurence.

### Tackiness

This designation is given to the soft, sticky character possessed by low-grade, crude rubbers. In the case of raw Guayule this is due to the presence of resin to the extent of about 20 per cent, and the effect may be corrected to a considerable degree by simple deresination. In other cases the sheets of rubber are seen to melt and become semi-liquid when placed in the vacuum dryer; or, if exposed in a drying loft the sheets drop off the poles. This may be due to (1) depolymerization, (2) oxidation, by air and sunlight. It is probably not due to bacterial action or to the presence of carbohydrates.

### Decay.

It has been noted that crude rubber will *perish* or decay if exposed to oxidizing influences. In the case of low-grade rubbers the development of an acid smell is noticed, the rubber first softens and later becomes hard and brittle. This defect is induced by the action of heat and light. It should however be noted that rubbers rich in resins are not always the most liable to oxidation.

### Loose-Sleeve Effect

This condition is noticed in the case of rubber-covered rolls. When the roll is put into service as part of a machine in the textile or the leather industry, the rubber compound works loose from the metal core of the roll. This may be due to careless vulcanization, or to the unsuitable character of the compound used for the "base," the part directly adjoining the metal. Aside

from this it may be due to the fact that the metal roll was not wiped free from grease, or the naphtha used for wiping the roll may have contained too high a percentage of non-volatile oil. In the latter case a film of oil remains on the metal core and the rubber compound fails to adhere to the metal. The defect may be avoided by eliminating the causes.

### Defective Friction

This is noticed as poor cohesion between the plies of coated duck in the case of belting, hose, auto tires and the like. It may be due to (1) the moisture in the cotton duck, (2) the unsuitable character of the friction compound, or (3) to improper method of vulcanization. The defect is especially objectionable in the case of auto tires. Here the numerous pulling forces on the layers of cotton duck make severe demands on the friction compound. To avoid defective friction the indication is therefore to use a compound containing a sufficient quantity of good rubber and to dry the cotton fabric before it is coated.

### Dry Friction

This is sometimes designated as "dead friction." It is due to the fact that not enough tacky binder has been used in the friction compound, or it may be due to over-vulcanization.

### Boot Leg

This phrase is applied to belting, where the middle plies of cotton duck have become separated during use on the pulleys. It may be caused by dry friction, or defective friction or by the incorrect manner in which the belt was run on the pulleys. The edges of the belt remain connected, so that the belt appears as a hollow body open at each end.

### Under-Vulcanization

Compounds which have been under-vulcanized, or under-cured, as it is called in the factory, are recognized as soft and flabby with negligible tensile strength and no marked elasticity. When such articles are stretched they do not come back to their original form readily. An expert would say that their "permanent set" or *permanent elongation* is high. Under-vulcanization may be due to (1) the use of an insufficient amount of sulphur, (2) the use of an insufficient amount of accelerator, (3) the short duration of the vulcanizing process, or (4) to the temperature at which the compound was vulcanized.

### Over-Vulcanization

If a compound appears hard and stiff when removed from the vulcanizing chamber, this may be due to over-vulcanization (over cure). In this case the product would show good tensile strength, but it could not be stretched very far without rupture. Over-vulcanization should be carefully avoided, as it cannot be corrected, whereas in the case of under-vulcanized products, where the defect is due to too short a cure or to too low a temperature, this may be helped by subjecting the product to further vulcanization. The defect may also be caused by the use of excessive amounts of vulcanizer or vulcanization accelerator. It is especially undesirable in such articles as steam hose for railroads, steam packing, power-transmission belting and auto tire treads. As these products are subjected to high temperatures after they are put into use they should rather be slightly under-cured in the factory.

### After-Vulcanization

This is seen in articles which contain an unusually large amount of free sulphur, or products which are subjected to high temperature while in use. The remedy or rather the preventive is to use less sulphur and less accelerator. At the same time the vulcanization should be effected rather by a long cure at a comparatively low temperature.

### Slow-Vulcanizing Compounds

This defect is noticed in those compounds which contain a large percentage of retardants. These agents have a preferential affinity for the sulphur so that the rubber does not have an opportunity of combining with its allotted portion. If it is necessary to use retardants in order to produce a given effect in the finished product, care should be taken to incorporate in the recipe an accelerator as a corrective.

### Dry Mixings

This is observed on the mixing mill during the mixing of compounds containing a large proportion of such dry fillers as whiting, infusorial earth, magnesia, asbestos and the like. In some cases a compound may mix easily on the mixing mill, but when fed into a tubing machine, the tube which is extruded (squirted or forced) through the die will have a tendency to crumble. In compounds which show these signs it is fair to assume that the absence of soft fillers has prevented the necessary cohesion and adhesion among the particles. It may be caused by the use of excessive amounts of dry mineral fillers or of reclaimed rubber. Reclaimed rubber stock containing as much as 50 per cent mineral matter, with 50 per cent rubber and organic matter is sometimes found to be very "dry" when run on the mixing rolls. The defect of dry mixings may be corrected by adding to the recipe such lubricators as black oil substitute, white oil substitute, petrolatum, unoxidizable vegetable oils, paraffin wax and pontianak.

### Micro-Porosity

This defect is observed as small holes the size of a pin prick, which appear all through the finished product. It may be caused by the presence of air or moisture in the rubber dough previous to vulcanization. It may be corrected by the addition of paraffin wax, vegetable waxes, or asphaltum products to the recipe. If due to moisture, the mineral powders must be dried carefully before being used for compounding. The defect of micro-porosity is especially objectionable in articles which are to be used under pressure: air-brake hose; signal hose; vacuum hose.

### Discoloration

This is observed as a grayish cast on products which were expected to come out a pure white or a bright red. For example, in cases where a high-grade white product is desired, zinc oxide is the preferred mineral filler. But if the zinc oxide contains lead compounds, an

impure white or even a gray product will be obtained, depending upon the actual amount of lead present in the mineral powder. As another example we have the case of crimson antimony sulphide, commonly used wherever a bright red-colored product is desired. If the antimony sulphide contains lead compounds, the resulting product will have a cloudy red color. The defect can be readily prevented by testing the zinc oxide and the antimony sulphide for the presence of lead before it is used.

### Blooming

Of all defects observed in rubber goods, this is no doubt the most common. It refers to the separation of sulphur on the surface of the goods, and is still regarded by some buyers as a "good sign" of a well-made product. Salesmen frequently find it impossible to sell hose to some consumers unless the outside is liberally coated with sulphur crystals. This coating of fine sulphur is caused by a wandering of the excess sulphur to the surface. This is the free or uncombined sulphur. The bloom may be avoided by reducing the amount of sulphur in the receipe, or by using catalytic agents, or by reducing the amount of organic retardants in the recipe. If it is desired to remove the deposit from the finished rubber goods, this may be done by boiling the finished article in a weak solution of caustic soda. This operation is frequently carried out with rubber stoppers, which are to be used for chemical laboratory work. Bloom is especially objectionable in the case of articles used for food or medicinal purposes.

### Blistering

If moisture is contained in the powdered mineral fillers, or in the raw rubber, this will produce the effect known as blistering when the compound is vulcanized. In extreme cases pronounced sponginess results. The defect in the majority of cases may be avoided easily by eliminating the cause. If the compound contains any substances which are volatile at the temperature of vulcanization, these will produce a similar effect. The plan then should be to avoid in rubber mixings any substances which might *volatilize* at a temperature of 300 deg. Fahr.

### Ageing

This term is commonly applied to the drying-out or hardening of rubber products which are exposed to certain conditions. In the simplest case it is due to the recipe used, and for that reason the compounding man should be well aware of the conditions under which the compound is to be used, that is, the *specific* conditions. The ageing or surface hardening may be traced to any one of several fillers used in the compound, to the factors of time and temperature during vulcanization, or to the influences of temperature, light and air to which the finished product is exposed when in service. It has been difficult to devise a *laboratory* test which would take the place of the *service* test for this defect. And this fact in itself shows how difficult a problem it constitutes. One thing has been definitely established: the use of certain hydrocarbons in proper proportions will insure longer life for the product. These hydrocarbons include pitch products obtained from petroleum, coal tar and gilsonite, either alone or mixed. The decomposition, decay or death of a vulcanized rubber compound is influenced to a very considerable degree by the temperature to which it is exposed when in service. For that reason the life test usually applied in the laboratory to predetermine the liability of goods to decay consists in exposing the sample to definite higher temperatures for a definite time.

### Swelling

This defect is found in packings used in connection with tanks where animal or vegetable extracts or fats are stored. Such substances as tanning extracts and beer extracts have a definite swelling action on some packings, and this is undesirable. Then again a hose used for conveying gasoline should not swell to any appreciable extent. This non-swelling property is secured by a careful choice of compounding materials, for it is a matter of common knowledge that rubber itself will swell appreciably when placed in gasoline (petroleum naphtha).

### Permanent Elongation

This is observed in products which have been under-vulcanized, or which contain a very small percentage of new rubber, a large percentage of reclaimed rubber, or such gums as pontianak. Washed and dried pontianak contains possibly 25 per cent of actual rubber substance so that a compound made entirely of this will show little or no "come-back." In other words, the *permanent set* will be considerable. For example, if a test specimen be vulcanized and scribed with marks 1 in. apart, and the specimen then pulled apart in a testing machine, it will be noticed that the specimen will stretch to a considerable distance without rupturing, but when the pull is released the specimen will not return to its original position. The permanent elongation is excessive. For that reason pontianak gum exclusively is not used for the manufacture of commercial products. It may be stated as a general rule that the less permanent elongation which a product exhibits, the more valuable is the product. For this reason it has become common practice when drafting specifications to place a limit on the "permanent elongation."

### Stretch

The ability to stretch and then come back and resume approximately its former position is a characteristic property of a well vulcanized, good rubber compound. Hard-rubber compounds are obviously excluded from consideration at this point, although they do show the physical property of *elasticity*. The percentage of stretch possessed by a rubber compound bears a certain relation to the amount of rubber which it contains. Hence it has become customary to carefully determine this property when the relative value of rubber products is to be ascertained. A finished rubber compound which will show little or no stretch is obviously defective, provided that the compound is intended for use where elasticity is an important factor. For it is quite possible to imagine cases where the compound would be used merely as an insulating layer, where the question of stretch would be relatively unimportant.

### Tensile Strength

This is a property exhibited in varying degree by vulcanized rubber compounds, and it may well be considered a measure of the quality of the product. If

the strength is defective, this may be due to the use of an insufficient amount of sulphur, accelerator, or rubber; or the compound may be under-vulcanized or over-vulcanized. It may well be said that this property is one important indicator of successful manufacture. The interdependence of tensile strength and stretch must be recognized and taken into account at all times. If one is increased the other will be diminished, and the reverse is likewise true. The object then would seem to be this: To discover the one point in the vulcanizing process where the required amount of tensile strength is secured, and a maximum amount of stretch is obtained. For example, it is possible to specify that a rubber compound is desired which possesses a tensile strength of at least 300 lb. per square inch, and the stretch shall be not less than 1 in. to 7 in. If then a series of compounds all show a stretch of 1 in. to 7 in., that one will be the best which possesses the greatest tensile strength. For example, three different varieties of good rubber when vulcanized under the same conditions show tensile strength tests of 2830 lb., 3055 lb. and 3170 lb. It must, however, be added that this test does not indicate whether the life of the compounds is in the same ratio as the tensile strength figures.

The Rubber Trade Laboratory,
Newark, New Jersey.

# Manufacture of Nitric Acid

AT A MEETING of the Delaware Section of the American Chemical Society at Wilmington on March 8, Dr. Edward Hart of Easton, Pa., delivered an address on nitric acid. Dr. Hart is one of the pioneers in the distillation of nitric acid and the inventor of the Hart condenser. He said it had been his lot at various times to be called into consultation by men of affairs, heads of manufacturing industries, in such a way that he could gage with a fair degree of accuracy the methods they were pursuing. He said he had never come in contact with men organized on better lines or pursuing methods better calculated to bring success than those of the chemical organization which overshadows Wilmington.

One little seed which he planted there many years ago has grown under its fostering care, he said, and has developed until the old boy who planted it can scarcely recognize his child.

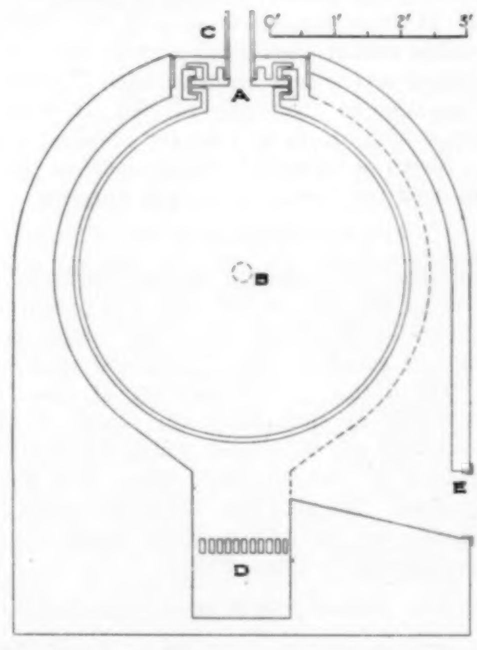
There has developed, too, one of the humors of the situation, for what has come to him of the methods of operating, has come through roundabout channels, and he had never seen his nitric acid plant running in Wilmington.

About the year 1893, in response to a request from the du Pont de Nemours Company, he visited Wilmington, aw Mr. Jackson, and sold him six condensers. Shortly after he turned the propaganda work over to others and devoted himself to purifying nitric and hydrochloric acids for which he invented automatic apparatus, still industriously at work.

Out of those six condensers with ½-in. tubes have been developed the present batteries which for several years have been turning out the sea of nitric acid that is so potent an instrument in our chemical transformation as a nation.

In taking up the history of nitric acid, Dr. Hart referred to the preparation by the latin Beber (Nuremberg edition, 1545), which seems to have been the first. Georg Agricola described its preparation in the first edition of De Re Metallica (Hoover's Trans.). Lazarus Erckers described the preparation of aqua fortis in 1574 in The Beschreibung aller Fueremsten mineralischen Ertzt und Bewercksarter (also in edition of 1580). Glauber, after whom Glauber's salt is named, was the first to prepare hydrochloric acid from salt and sulphuric acid. He also prepared nitric acid from saltpeter and sulphuric acid, although he did not directly describe either process. Caspar Neumann also described the preparation of nitric acid from niter and sulphuric acid (Trans. by Wm. Lewis in 1759). In 1848 Dumas also described its preparation in Traite de chimie applique aux arts, Tome 7, p. 283.

About 1890 Dr. Hart began to make nitric acid. At that time the firm of Baker & Adamson, in Easton, Pa., of which he was a member, had been buying nitric acid and refining and selling the chemically pure article. The acid came to them on flat cars in carboys




Explanation:

A = Retort Neck
B = Trunnion
C = Stoneware Pipe for $HNO_3$ Vapor
D = Grate
E = Opening for Discharge Trough

FIG. 1

Hart's Nitric Acid Retort.

and they had so much trouble from breakage and so many of the men were burned that they decided to make their own acid from nitrate of soda and oil of vitriol, 66 deg.

Being dissatisfied with the retort figured in the books, Dr. Hart devised one very much like that shown in Figure 1, 4 ft. diameter and 4 ft. long. It had about eight ½-in. holes bored in the top plate, and after the charge was made eight Liebig glass condensers were fastened in the holes, four on each side of the furnace. Then the fire was started and the trouble began. A 2-gal. bottle was placed under each condenser and soon

yellowish-red fumes of nitrosyl chlorid were pouring from each bottle and forming a pool in the room. It was evident that the condenser system would not do, but it was not until some time later that the first Hart condenser was devised, erected, and patented. At first they had a great deal of trouble with boiling over until it was discovered that the two boys running the apparatus were systematically forcing the fire so as to make it boil over to get short hours. After replacing them this trouble disappeared.

Dr. Hart's first publication on the subject was in the *Journal of Analytical and Applied Chemistry*, of which he was the editor (Vol. 5, 1891, p. 382). Two papers were then published simultaneously in the *Journal of the American Chemical Society* which he then edited (Vol. 17, 1895, pp. 576, 580). In these papers he dealt with condensation generally and described the condenser as patented. It had fifteen 1-in. tubes 6 ft. long and condensed 785 lb. acid from 1000 lb. niter and 1000 lb. oil of vitriol, 66 deg., in six hours actual running time with 150 lb. pea anthracite coal.

According to the census of 1900 the production of nitric acid in the United States was about 15,500 short tons, most of which was used in the manufacture of nitroglycerine and guncotton. This has, of course, vastly increased and, since the great war began, by leaps and bounds. Dr. Hart pointed out that until nearly 1900 there were only a few large producers. Most installations were of only one or two retorts, and little effort was made to save the bleeder gases (mostly $NO_2$). The conversion of this gas into $HNO_3$ is a difficult operation, for it involves absorption in water and oxidation with atmospheric oxygen. Since the latter is mixed with four times as much nitrogen and is only slightly soluble in water, large surface is required and high yield can hardly be expected. This part of the subject is best studied in connection with synthetic nitric acid. He called attention to the Guttmann process in which thin earthenware tubes are used for condensation and the Valentiner process in which distillation takes place in a vacuum. He has already detailed these methods in the article on nitric acid which he wrote for Sir Edward Thorpe's Dictionary of Applied Chemistry. The latest method is that of Hough, who uses a duriron condenser. Most of the acid from Chile saltpeter is being produced in some modification of the Hart condenser. The latest form of this apparatus for large installations is shown in Figure 2. In the early condensers asbestos was used as a lute between tube and manifold. This has been displaced by putty. Dr. Hart did not know who invented this putty, nor who devised the pulsometer and dash pot operated with compressed air used for the condensing towers.

There is one property of nitric acid which demands special attention. Under certain conditions it is a strong oxidizing agent and since one set of products of the operation is nitrogen oxides which may be regenerated it is entirely possible that this will repay further study.

If cotton is treated with strong nitric acid, we get nitric esters. The oxidizing action is negligible. Since cotton may be considered an alcohol, we should expect the same result from other alcohols. With ordinary ethyl alcohol we do in fact get ethyl nitrate, but this manufacture should not be attempted on a large scale the first time. If all oxides of nitrogen dissolved in the nitric acid are destroyed by adding a little urea the reaction then goes smoothly and we get pure ethyl nitrate. Without the urea we might go out the door by way of the window. When aromatic compounds like benzene are treated we get a different class of substances: the nitro compounds, in this case oil of myrbane. The oxidizing effect which is of the third class is most pronounced when the nitric acid is diluted. For example: strong nitric acid and phenol give the nitrophenols. But dilute nitric acid boiled with phenol gives beautiful yellow crystals which on examination are found to consist almost entirely of oxalic acid.

Dr. Hart said if he ever gets the time he wants to see whether it is possible to make oxalic acid in quantity from cheap organic material, like sawdust for example, by boiling with dilute acid and regenerating the oxides. To all intents and purposes, working in this way we would get our oxidation at the expense of atmospheric oxygen. This would be an especially attractive idea where waste power is available, for example where power is used for operating trolley lines where the peak comes at 6 a. m., 12 m. and 6 p. m., with practically no load from 12 p. m. to 5 p. m. During the five-hour interval of no-load the power would be at work generating oxides of nitrogen to compensate for unavoidable losses.

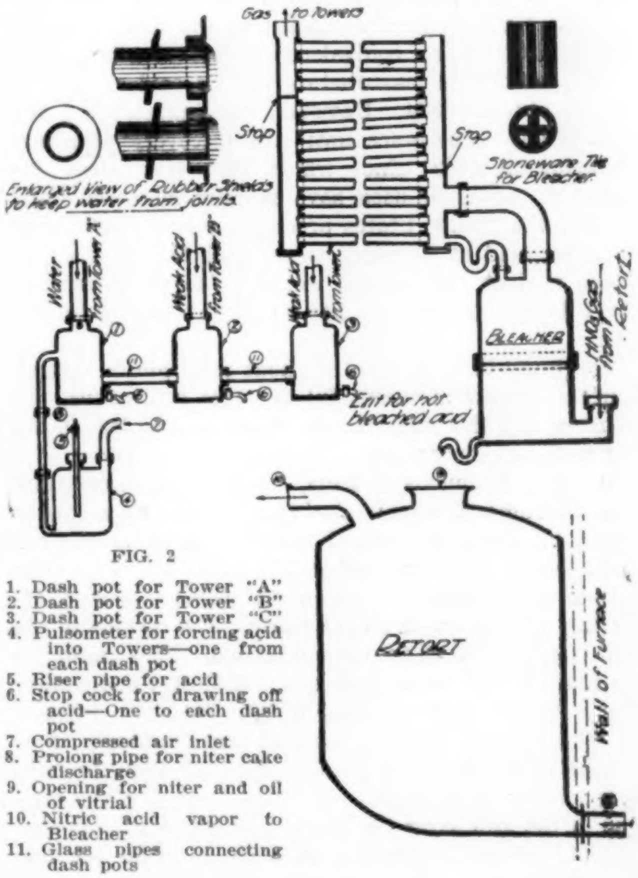



FIG. 2

1. Dash pot for Tower "A"
2. Dash pot for Tower "B"
3. Dash pot for Tower "C"
4. Pulsometer for forcing acid into Towers—one from each dash pot
5. Riser pipe for acid
6. Stop cock for drawing off acid—One to each dash pot
7. Compressed air inlet
8. Prolong pipe for niter cake discharge
9. Opening for niter and oil of vitrial
10. Nitric acid vapor to Bleacher
11. Glass pipes connecting dash pots

He said he was satisfied that fields like this will yield a rich reward to the successful cultivator, and that as the years go by nitric acid, ammonia, and the other nitrogen derivatives will play a larger part in our future.

In this connection an interesting article by W. Ed.

Burkhard has just appeared in the March number of the *General Chemical Bulletin* which will supplement very well the data given by Dr. Hart. Mr. Burkhard says that without this acid we should not have all our beautiful variegated artificial colors and dyes but would be limited to the comparatively few serviceable natural dyes; we should also be without some of our finest lacquers, artificial silk, collodion, celluloid, nitroglycerine, dynamite, T.N.T. and so on for an almost unending list of extremely valuable materials. He says that until very recently all the commercial nitric acid in the world was made from saltpeter brought from Chile.

The refined nitrate as used in acid manufacture has from 92 to 98 per cent $NaNO_3$, generally 95 to 96 per cent. For this purpose it should not contain over 1½ per cent NaCl as in the distillation the muriatic acid formed destroys an equivalent amount of nitric acid.

The commercial manufacture of this acid started in this country in 1824. However, this industry did not assume any importance until the discovery of nitroglycerine in 1862, since which time the money investment and labor used have steadily increased until in 1915 the United States produced nearly 80,000 tons of nitric acid at fifty-two works and 112,000 tons of mixed acid at thirty-seven works. The world demand for nitrogen compounds has risen to 750,000 tons a year.

There are three general methods for manufacture of nitric acid now in successful use—the continuous, the vacuum, and the atmospheric pressure. The last is the one in most general use.

In the continuous process, which was successfully used in England, the nitrate is mixed with an excess of $H_2SO_4$ in a separate vessel where solution is effected and chlorine and nitric oxides are given off. This mixture flows continuously into a still which is heated, effecting distillation of all the nitric. The residue in the still is drawn off at frequent intervals. They claim the distillate to run 94 per cent nitric acid of a fine quality and a "soup" of 30 per cent $H_2SO_4$. However, in spite of all the good qualities claimed and seemingly theoretical advantages, the process does not seem to have found favor in America. The "nitre soup" is the residue in the still after the nitric is distilled off. It consists of sodium sulphate with from 20 to 30 per cent free $H_2SO_4$, very often approximating an acid sulphate, *i.e.*, $NaHSO_4$.

The vacuum or Valentiner process is successfully used in this country to some extent. This process is identical with the common atmospheric process except that it is operated under a vacuum which, of course, means a lower distilling temperature. However, in order to expel the last trace of nitric acid the final temperature is nearly the same in both cases, approximately 175 per cent—250 per cent C. In the vacuum process all leaks suck in air, thus rendering more difficult the complete condensation of the acid, but the plant is remarkably free from fumes, which is an important factor. Also, a gang of repair men must be constantly on the alert, for leaks do not show themselves as in the common process.

The soda and acid, generally 66 deg. Bé. $H_2SO_4$, though stronger acid is sometimes used, are charged into an iron still. The size and design differ widely. The sulphuric acid is usually calculated so that the "soup" will be as fluid as possible at as low a temperature as practical to prevent excessive corrosion. The normal acid sulphate fulfils these conditions. The heat is applied gently to the stills to prevent boiling over and the gases are condensed. By fractionating the condensate, acids of various strengths and purity are recovered. The impure acid is purified from its volatile impurities such as iodine, chlorine and nitrous acid (which gives it color) by bleaching, which is simply boiling and drawing off the impure vapors.

The process for the future is the synthetic, which promises to put the soda or decomposition process in the second place. The raw materials, air and water, are to be had for the taking. Since the war started Germany has been denied all imports of soda and so would have been quickly forced to the wall for lack of explosives had her chemists not risen to the occasion and made practical the industrial synthesis of this acid.

Most nitric acid is used for nitrating, that is, introduring the $NO_2$ group into organic compounds. As this action produces water, the acid is quickly diluted and loses its power. To overcome this mixed acid is used. This is a mixture of either ordinary or fuming sulphuric acid with different strengths of nitric.

The greatest demand is for high-grade acid of between 36 and 44 deg. Bé., *i.e.*, 52 to 74 per cent acid, although as low as 30 deg. is made. Also, one grade over 52 deg. is made, which is very strong nitric saturated with $N_2O$ and is called fuming. It is claimed to have greater oxidizing power. Nitric acid can only be satisfactorily shipped in glass carboys, although mixed acid can be shipped in steel tanks.

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**Production of Platinum in the United States in 1917.**—According to figures compiled by J. M. Hill, of the United States Geological Survey, Department of the Interior, only 605 ounces of crude platinum was sold by placer mines in 1917. This is less than the sales in 1916 by about 100 ounces. The imports of crude platinum amounted to 31,921 ounces, not counting the 21,000 ounces of Russian crude platinum which was received by the Government late in December.

During 1917 refiners made about 33,000 ounces of platinum, 4,800 ounces of palladium, 833 ounces of osmiridium, and 210 ounces of iridium, which can be called "new metals." Of this amount about 7,400 ounces probably originated from domestic materials.

The saving of scrap platinum of all classes resulted in much larger recoveries of secondary platinum metals than in previous years, a total of 72,000 ounces being recovered, as compared with 48,000 ounces in 1916.

**Potash from Seaweed in South Africa.**—Mr. Gilbert F. Britten, in the course of a paper contributed to the South African *Journal of Science*, says that of the enormous growths of seaweed along the shores of the peninsula, experiments indicated that the kind known as "sea bamboo" could be utilized for the production of potash. It was found that there were not, generally speaking, very great differences in the chemical composition of the various specimens, and while South African bamboo is on the whole lower in potash content than American kelp, it is decidedly better in composition and may prove a worth-while source of potash.

# Potash from Wood Ashes

## Production in Michigan and Wisconsin

BY C. T. EDGAR[1]

ON March 2, 1917, a number of potash manufacturers from Wisconsin and Michigan met at Wausau, Wisconsin, to organize for their mutual interests. These men formed the Northern Potash Association, which includes in its membership upwards of twenty potash plants.

The primal purpose for the meeting at this time was to deal with tariff problems, which greatly concern the future of the industry. But equally important was the need of co-operation, and the discussion of many matters in relation to an industry that has developed in somewhat mushroom fashion, yet up to the present has remained disorganized. By that I mean as well that the industry in this country as a whole has remained disorganized.

The Association referred to is sectional, and while it probably comprises the majority of those connected with the manufacture of potash from wood ashes, the total production from that source is still small, and its development has been inconsiderable compared with that of certain other fields, such as California and western Nebraska. The Northern Potash Association is endeavoring to encourage the organization of manufacturers in other sections of the country, to increase production where practicable, aand to assist the Government in any way that it can for the carrying on of the war. Its efforts have met with a gratifying spirit of co-operation.

The amount of potash produced in wood ash plants is not large, comparatively. But the number of such plants has greatly increased, and this increase has been made for the most part in the short space of two years. From three or four plants doing business in the early period of the war the number of such plants is now increased to around fifty in Wisconsin and Michigan alone.

Exact production figures for this district are not yet available. A representative number of plants, however, report an output ranging from 1500 lb. to 4000 lb. a week at each plant. The average is closer to the smaller figure. A conservative estimate would place the production of potash salts in Wisconsin and Michigan at 3,900,000 pounds annually, having a value of $1,170,000 at present prices.

The recovery of potash from wood ashes was quite an extensive method of manufacture at an earlier period. Some idea of this production may be gained from the fact that in 1850, 27,000,000 lb. were exported from Canada alone. Since 1870 the wood-ash product has been largely displaced by the mineral salts from the German deposits.

The crude form of potash produced from wood ashes is known to the trade as "potash first sorts." It consists of a soluble portion of wood ashes, obtained by a process of lixiviation. The salts are dissolved by soaking the ashes in water and drained off through a lime filter, after which the solution is evaporated and reduced to solids by heating. The product is usually sold in tight wooden barrels containing from 600 to 800 pounds to the barrel and is in the form of fused, chunky masses, having something of the appearance and hardness of stone. It absorbs moisture and will become liquid if it is exposed to the air long enough. The color is a greenish gray, with variegated hues of red, brown and blue. The coloring is due to small portions of iron and manganese, and carbonaceous impurities.

The equipment necessary for producing these salts is inexpensive and very simple. I have known many instances in which persons entirely unfamiliar with potash have constructed plants and put their product on the market within thirty or forty days after their interest was first attracted to the business.

The usual cost of a plant is about $3000. The general plan consists of an elevated platform supporting tubs, or leaches as they are called, and a "melting" room which contains the furnace and kettles. The leaches are usually from twenty to thirty in number, either square

[1]President, Northern Potash Association.

FIG. 1. POTASH PLANT AT ANTIGO, WIS. THE ASHES ARE LOADED AND REMOVED THROUGH THE SMALL DOORS ON THE SIDE OF THE BUILDING

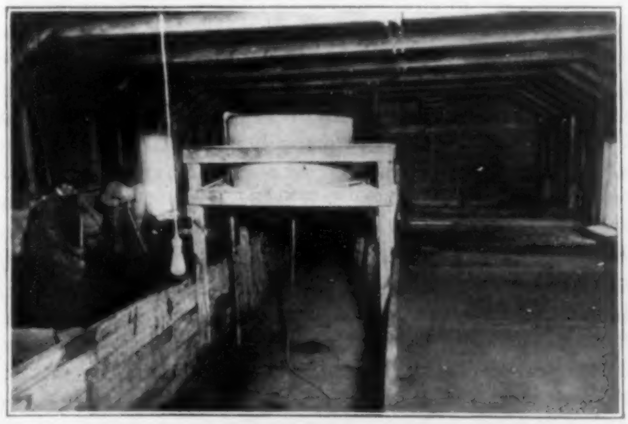

FIG. 2. LEACHING ROOM, ANTIGO POTASH CO. THE LEACHES ARE WATERED BY GRAVITY FROM THE TANK IN THE CENTER

FIG. 3. MELTING ROOM, ANTIGO POTASH CO. ON THE LEFT IS SHOWN THE KETTLE IN WHICH THE "MELT IS COMPLETED AND THE TWO IRON MOULDS"

or round, constructed of wood with sloping metal bottoms. The round leaches, or tubs, are preferable to the square boxes, because when rotted or old they can be removed and replaced separately without interference with the adjoining leaches. They are about 4.5 ft. high and 5 ft. wide and are preferably arranged in rows on either side of the platform. This permits the used ashes to be thrown from them through little openings on the exterior walls of the building and on to wagons or conveyors, whence the leached ashes can be taken to the place of dumping.

Frequently the space through the center of the room between the rows of leaches is used for storing ashes and in the ordinary plant will conveniently store 100 tons or more at a time. Beneath the platform are metal troughs on each side running the length of the rows of leaches. The bottoms of the leaches should slope so as to be 4 to 6 in. lower at the side situated over the trough. Small holes are bored on a level with the lower ends of the leaches so as to permit the liquid to drain from the leaches into the troughs.

Before filling the leaches the filter, consisting of straw and lime, is placed on the bottoms. Rye straw is preferable. After the straw is laid on a thickness of several inches, slack lime is smeared over the surface to the extent of one inch. The leach is now ready to be filled with ashes. The ashes should be tamped down as uniformly as possible so as to insure perfect soaking. Water is run over the leaches several times a day for about four days. The ashes continue to soak up water and a process of fermentation is going on. After this period a reddish-brown liquor begins to drip from the bottoms of the leaches into the lye troughs. The ashes are watered two or more times a day and the liquor continues to drain from the leach for a period of eight to ten days after it has started to run. By that time the solution becomes weaker, the old ashes are thrown out and the leach freshly filled. The filling of the leaches is generally done in rotation so as to maintain a constant flow of lye. The strength of the ashes of any particular leach can be easily determined by the use of an alkali hydrometer, by taking the specific gravity of the lye which flows therefrom. The lye from a fresh leach will test around 20 per cent. When the test shows only one or two per cent the leach should be discontinued and the ashes thrown out.

The lye flows through the troughs into the "melting" room into evaporating pans or kettles, which for several days are kept constantly full. The evaporation is facilitated by the heat from the furnace which is usually waste heat so directed as to pass under the evaporating pans. As the solution becomes thicker it is transferred into a larger kettle, which is fitted over an enclosed brick furnace. The mass is now subjected to a powerful heat for a number of hours during which gaseous matter is driven off, combustible impurities are for the most part burnt out, and a fusion takes place. When the fusion is complete, the liquid becomes quiescent, and has a reddish glow like melted iron. It is then transferred, by means of large iron ladles, to iron pots and congeals in cakes. The pots are usually of such size as permit the cakes to fit into barrels for shipment.

The proportion of potash contained in wood ashes is not constant. The analysis of the potash salts therefore varies considerably in the proportions of potash compounds. The greater portion of these salts, however, consists of potassium carbonate, particularly in a converted form of potassium hydroxide, due to the contact with lime. An analysis follows:

| | |
|---|---|
| Potassuim Hydroxide | 65.64% |
| Potassium Carbonate | 16.58% |
| Potassium Sulphate | 16.03% |
| Potassium Chloride | .35% |
| Moisture and insoluble | 1.40% |
| Alkalinity as Potassium Hydroxide ($K_2O$) | 79.10% |

The price of ashes in saw-mill localities and wood-burning communities varies from $2.00 to $6.00 a ton. About two cubic yards, not compressed, comprise a ton. Hardwood ashes are preferred to those in which the ash of soft woods predominates for the reason that the principal hardwoods apparently contain a greater percentage of potash. Woods' Dispensatory contains a table indicating the percentage of potash recovered from the ashes of various plants. It is stated therein: "Ligneous plants yield less than herbaceous, the trunk less than the branches, and the branches less than the leaves. The bark yields more ashes than the wood, and the leaves of trees which drop their foliage in winter yield more than the leaves of evergreens." Following is the table referred to:

| | |
|---|---|
| Pine | 0.45 |
| Poplar | 0.75 |
| Birch | 1.29 |
| Beech | 1.45 |
| Oak | 2.03 |
| Box | 2.26 |
| Willow | 2.85 |
| Linden | 3.27 |
| Elm | 3.9 |
| Maple | 3.9 |
| Wheat Straw | 4.18 |
| Flax | 5.0 |
| Rush | 5.08 |
| Common Thistle | 5.37 |
| Vine Branches | 5.5 |
| Barley Straw | 5.8 |
| Beech Bark | 6.0 |
| Fern | 6.2 |
| Indian corn stalks | 17.5 |
| Sunflower stalks | 19.4 |
| Dry oak leaves | 24.0 |
| Common nettle | 25.0 |
| Black elder | 25.5 |
| Vetch | 27.5 |
| Poke | 45.6 |
| Wheat stalks | 47.0 |
| Stems of potatoes | 55.0 |
| Worm wood | 73.0 |
| Fumitory | 79.0 |
| Angelica | 96.2 |

One difficulty of the wood potash maker is in the conservation of the ashes. He finds that the people who make the ashes are not greatly interested in saving them notwithstanding that the price may be high. Many economical improvements could be made were the business a permanent one, but the potash makers have thought it was a business that would be killed by foreign competition some time following the close of the war and are therefore unwilling to make improvements.

Wausau, Wis.

# Fulton's Electric Zinc Furnace

THE METALLURGICAL LABORATORIES, Inc., has been experimenting for about a year and a half with the zinc-smelting process devised by Dr. Charles H. Fulton of Case School of Applied Science, and patented by him early in 1916[1]. During the twelve months following September, 1916, Dr. Fulton personally directed the experimental work at East St. Louis, with satisfactory results. At the present time the plant contains an intermittent furnace of commercial size, operating on various oxide and silicate ores, determining the proper mixtures for briquetting, the current requirements, and the condenser design capable of liquefying the tremendous volume of vapor produced. The furnace now in operation is practically that described in patent No. 1,242,337 (Oct. 9, 1917), which, together with others recently granted (1,242,339 to 41, and 1,249,061), gives a large number of details concerning their experiments.

With reference to Fig. 1, the furnace is an electric resistance furnace, consisting of the movable cylindrical steel shell (1) closed at the top, lined with refractory material, and the open bottom resting on a fixed base *B*, the passages 10 being heated by a gas flame. The dried ore, with suitable binder, is formed into briquets which constitute the resistors, and the electric current passing therethrough generates sufficient heat to raise the interior to such temperature as is necessary for the reduction of the zinc compounds and the vaporization of the metal. The finely divided zinc-bearing material (ore, blue-powder, or ashes) is mixed with pulverized coke for a reducer, and sufficient binder is added (tar or hard-coal tar pitch) to thoroughly coat the particles.

[1]A short description of the original patent was given in this Journal Feb. 1, 1917, p. 158

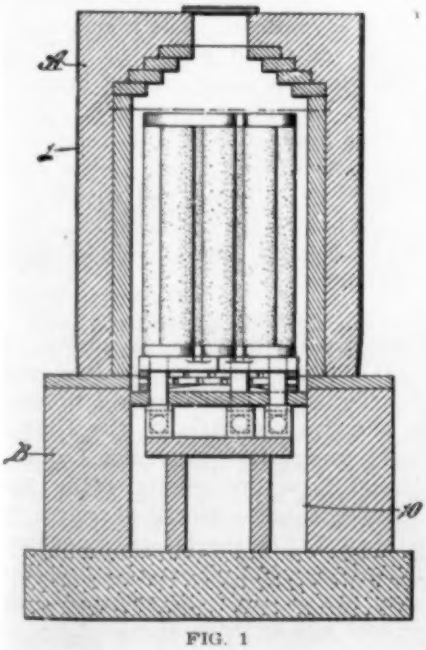

FIG. 1

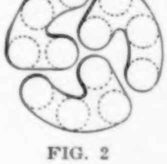

FIG. 2

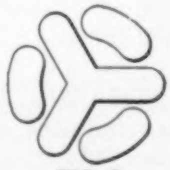

FIG. 3

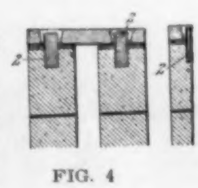

FIG. 4

Coke is the best reducer because it contains little volatile matter to be driven off preliminary to distillation, and gives off no gas during distillation. The particles also retain their form during the process, thus insuring the continued stability of the briquet. The relative proportions of coke and ore should be such that sufficient porous material will remain at the end of the heat to insure substantially the original volume of the briquet, and constitute from 40 to 50 per cent of the original weight. Binder to the amount of 12 to 15 per cent of the weight of the ore plus coke is sufficient if the latter is moderately fine,

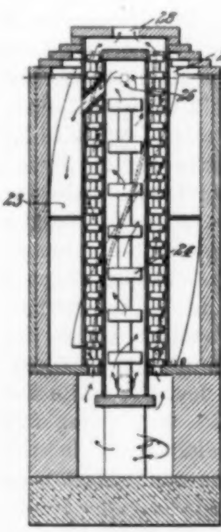

FIG. 5

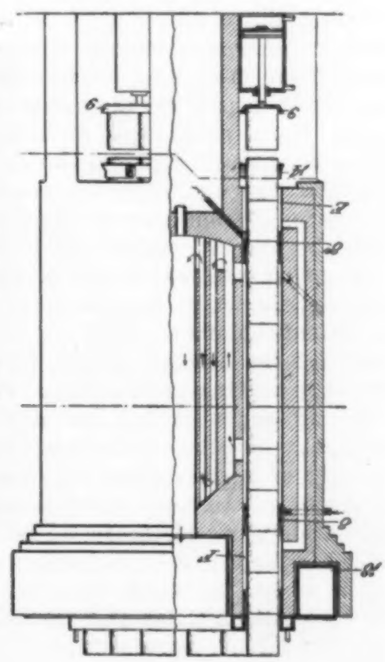

FIG. 6

i.e. will pass through a 10-mesh screen. The proper determination of the coke size is important, as fine coke produces strong briquets, but of low electrical resistance.

The hot mixture is compressed into rods, 12 inches in diameter and six feet long at a pressure of from 500 to 1000 lb. per square inch. They are then preheated in order to coke the binder and drive off the hydrocarbons before distillation begins. The briquets are properly supported during this process in order to maintain their shape; a neutral or reducing atmosphere is also essential to prevent the coke at the surface from burning and loosening into a friable layer.

The briquets may more easily be made in shorter sections, and cemented together at the ends by a mixture of 40 per cent of coal-tar pitch, and 60 per cent of fine graphite. In any case the final briquet is placed on end upon an electrode energized through leads built into the fixed bottom of the furnace. Top and bottom connections for a 3-phase star connection are shown in Figs. 2 and 3, the connectors being made of graphite (or of the ore-coke mixture) and pinned

to the top of the resistor as shown in Fig. 4. In this diagram 3 represents a filling of fine graphite; the construction being designed so that there is small danger of an open circuit at these points due to differential shrinkage of adjoining columns.

In operation, the baked briquets are assembled upon the bottom electrodes, and the top connections made. A preheated retort *A* is lowered over the whole, and current switched on. The energy input is relatively small until the whole interior of the retort reaches a temperature of from 700 deg. to 800 deg. C. when the current is rapidly increased until the distillation point is reached. The products of the reaction, zinc and carbon monoxide vapor in equal volumes, are drawn off in a quite pure condition through openings at the top of the base and discharged into a suitable condenser set nearby. A complete cycle requires 5½ to 6 hr., when the distillation is practically complete.

As can readily be imagined, the problem of condensing the zinc vapors is of extreme importance. Several designs of electric zinc furnaces can produce zinc vapor in large quantity, but none of them has been able to produce the proper yield in liquid metal —the vapor apparently solidifies as the solid blue-powder without passing through the liquid phase, much as happens in the formation of frost. In order to condense from a vapor, the temperature of the gas must be lowered beyond the boiling point of zinc at the partial pressure of the mixture, 870 deg. C. at ½ atmosphere, which exists when Zn and CO are present at equal volumes. The liquid product must not solidify; the absolute temperature minimum is therefore the melting point of zinc (419 deg. C), while the working minimum is more like 550 deg. C. or 600 deg. C. Another important consideration is the amount of surface necessary for the condensation of a given quantity of vapor; so-called "nuclei of condensation" are necessary. That is, if there be provided in a space a large number of points or "nuclei" upon which the vapor has condensed into a liquid, these small particles of liquid already formed facilitate the further condensation of the vapor. Some surface must now be provided for the "nuclei" to gather upon, and the liquid to coalesce into droplets.

As remarked above, electric smelting of zinc has produced considerable "zinc frost" or blue-powder. This may be due in some cases to the production of a zinc vapor mixed with a variety of other gases. The partial pressure and boiling point of zinc in the mixture is therefore lowered, and consequently the temperature limits of successful condensation are more narrowly restricted. Again, local hot spots or small arcs in the charge may vaporize minute quantities of other metals or metalloids which solidify almost immediately, forming a plethora of condensation nuclei. Or due to slightly oxidizing conditions existing in the condensing gases at the reduced temperatures, the tiny droplets may become sufficiently oxidized on the surface that they do not coalesce into a liquid.

Whatever may be the actuality of these controversial points, the condensers operating on Dr. Fulton's retorts will have to overcome them, and in addition absorb and radiate a great quantity of heat continuously. Supposing each retort to hold 12 briquets, each weighing about 600 pounds, and containing about 20 per cent zinc, which is entirely distilled and condensed in six hours, liquid zinc would form at the rate of 240 pounds per hour. Not counting the amount of heat radiated by the hot mixture of gas cooling from the temperature of the retort (1000 deg. C. to 1300 deg. C.) to that of the condenser (600 deg. to 800 deg.) the latent heat of vaporization of the zinc at the lower temperature (1,051 B.t.u. per pound) will amount to 252,000 B.t.u. per hour. Although Dr. Fulton's process gives a cleaner vapor than many other proposed schemes, actual figures on the real condensation accomplished would be very interesting.

Two condenser designs are illustrated in the patents, one being shown in Fig. 5. It consists of a central shaft containing several baffles (24). The gases from the retort ascend through this shaft, then into the outer chamber 23 where they are deflected up and down by spiral partition walls, the uncondensed gases finally escaping through openings 26, where the carbon monoxide may be utilized. In order that the condenser may operate within the rather narrow temperature limits necessary, the annular checker chamber between these two chambers may be heated by gas flames (or cooled by air blast as necessary) entering below and escaping through the top 28.

A continuous furnace and process is also described and patented (1,242,339 and 40) illustrated in Fig. 6. The annular furnace contains a series of briquets heated by the passage of electric current between the electrodes 8 and 8*a*, where sliding contact is maintained by granular graphite. As distillation proceeds, fresh briquet sections are fed into the distillation zone by the action of a plunger 9 and supporting clamp 14. Spent hot electrodes are removed from the top and set in the trough 18 alongside freshly made sections, to dry the latter. Further baking is effected as the briquet passes through chamber *E*, where a gas flame is maintained, together with chamber *F*; this also acts as a seal preventing oxygen entering the distillation chamber. The products of the reactions are drawn inwardly to the central condensing chamber shown.

These novel processes have many unique features which apparently offer advantages. The temperature of distillation can be controlled either by voltage regulation, or by changing the speed of the briquets travelling through the continuous furnace. This should lend itself to the production of zinc relatively free from cadmium or other impurities, as the cadmium-rich product could be collected and withdrawn early while the furnace is at a low temperature. The time of distillation, heat input and labor cost have been reduced to a minimum.

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**High-Grade Abrasives**—Tremendous expansion in manufacturing in 1917, particularly in the steel and metal industries, is reflected by the increased production of high-grade abrasive materials in the United States. A preliminary compilation by Frank J. Katz, United Seates Geological Survey, of reports on the production of emery, corundum, and artificial abrasives in 1917 indicates a total of 72,276 short tons, valued at $8,325,312, which is an increase of 33 per cent in quantity and 172 per cent in the value as compared with 1916. About 80 per cent was artificial abrasives.

# Stellite

## Alloys of Cobalt, Chromium, Tungsten and Molybdenum

By Elwood Haynes

It is a noteworthy fact that the metals found in their native state on the surface of the earth are, generally speaking, extremely rare. Besides meteoric iron and native copper, they include gold, silver, mercury, and the metals of the platinum group. If Nature produced other metals during the formation of the earth's crust, they have long since combined with other elements, and exist only as compounds, chiefly oxides, sulphides, arsenides, carbonates, chlorides, etc.

It is extremely desirable, however, to have for use metals or alloys which remain permanent under atmospheric conditions, and at the same time have such physical properties as will enable them to be manufactured into instruments and utensils for daily service. Metals which are not at all permanent in the air, such as iron, lead, mangenese, etc., produce compounds with oxygen or sulphur which remain practically unchanged under ordinary natural conditions for many centuries, but these compounds are not workable, nor in any way suitable to direct manufacture into implements for daily use. Their physical properties, such as strength, hardness, and workability, are not such as would recommend them for such instruments. Copper, alloyed with zinc, produces brass, and olloyed with tin, produces bronze, but none of its combinations is permanent in the air, and all of its alloys are inferior in strength and hardness to steel.

The so-called "noble metals" with the exception of silver, are permanent in the air, but are so rare that implements made of them would be extremely costly, particularly if of any considerable size.

### Desirable Qualities Sought in New Alloys

It was with a view to producing an alloy which would combine the permanence of the noble metals with the strength and hardness of steel that the writer made a long series of experiments, which finally resulted in the production of a series of such alloys.

As early as 1899, an alloy was produced by heating the mixed oxides of chromium and nickel with metallic aluminium. A small button was obtained which showed considerable malleability when cold and when polished exhibited a bright luster which was not dimmed when the metal was boiled in either strong or dilute nitric acid. Moreover, the acid showed not the faintest color after such test. This alloy was somewhat harder than untempered steel, and could be readily worked under the file or in the lathe.

The mixed oxides of cobalt and chromium were afterward reduced by the same method, but the little pellets of the alloy thus produced were thrown from the crucible by the violence of the reaction. A few of these were collected, and found to be very much harder than the corresponding nickel alloys. They showed the same resistance to nitric acid and were only attacked very slowly by hydrochloric and sulphuric acids.

Later, the mixed oxides were reduced by means of carbon, and it was found possible to cast the alloy into bars which showed remarkable strength, rigidity, and hardness, as well as complete immunity to all atmospheric influences. Polished samples of the alloy were exposed to the fumes of the chemical laboratory for months, and in some cases their surfaces became covered with a deposit of ammonium chloride, but this could be easily rubbed or washed away, and the alloy showed the same brilliant surface as before.

These binary alloys of cobalt and chromium were so hard that they would take a cutting edge, and could be used in the place of steel for pocket-knife blades and table knives. They were found to be malleable at a bright orange heat, even when the chromium content rose to forty-five per cent or more. These high chromium alloys were very hard to forge, but after forging into pocket-knife blades, for example, they showed extremely fine grain, high elasticity, and a hardness equal to that of the best quality of steel pocket-knife blades. The permanence, general utility, luster, and color of these blades are very remarkable.

### An Alloy Rival of Steel

This alloy may be truly termed steel's first rival, since it constitutes the first metallic combination yet discovered, so far as the writer is aware, which takes and holds an edge at least equal to that of the best steel, and at the same time it can be produced in almost any form in which steel is utilized. It is of course much more costly, owing to the high price of its constituents. This, however, does not preclude its use for the following articles: a. table knife blades; b. pocket cutlery; c. surgical instruments; d. dental instruments; e. small evaporating dishes; f. spoons, forks and scissors. Lancets made of this hard alloy are now in use by many expert surgeons, and are proving highly satisfactory for this purpose, since they are immune to all antiseptic solutions employed in surgical work, and at the same time take a keen edge, equal to that of the best tool steel.

The first paper was read on the binary alloys of cobalt and chromium, before the American Chemical Society, in 1910, at San Francisco.

ARTICLES MADE FROM STELLITE

Later, the elements tungsten and molybdenum were introduced into this alloy, either of which increased its hardness to a remarkable degree. In fact, alloys of this character can be made so hard that they will scratch any steel yet produced.

### Nature and Properties of the Alloys

Just what is the nature of these combinations has not yet been fully determined. They seem to consist, however, of a cement of the hard cobalt-chromium alloy, which binds together minute crystals, possibly composed of the double carbides of chromium and tungsten or chromium and molybdenum. The above is little more, however, than a conjecture, as no real proof of such an assertion has yet been made.

These alloys can be readily cast into various forms, and melt at a lower temperature than the binary alloys of cobalt and chromium. The most remarkable property of these triple alloys is their ability to retain a cutting edge at high temperatures, and it is for this reason that they excell all high-speed steels in their ability to perform rapid work on the lathe.

Lathe speeds which would instantly destroy the edge of the best high-speed steels can be readily maintained with stellite tools without injuring the cutting edge. This advantage is so pronounced that stellite is coming into very extensive use as a substitute for high-speed steel tools, notwithstanding its comparatively high price. Machine shop superintendents and production men generally, are keenly alive to the fact that because other costs in the manufacture are so much greater than that of the tools, they are fully justified and save large sums of money on labor, equipment, floor space, and so forth by using highly efficient tools.

The following articles have been made from the hard alloys: lathe tools, milling cutters, saws, drawing dies, boring tools, drills, etc. These tools must be cast to the proper form, as they can not be forged nor otherwise manipulated except by grinding. At first sight, it would seem desirable that the tools should be of such a nature that they could be tempered and forged, but a moment's reflection will render it evident that such a property would be detrimental, since in order that it might be forged, it would be necessary that it should soften under heat and would thus lose its most valuable property. The same would be to a certain extent true regarding tempering or hardening, since it is the inherent stability of the alloy at all temperatures which gives it its highly desirable qualities as a lathe tool.

At the instant of casting, and just as the metal is changing from the liquid to the solid state, minute crystals of extreme hardness are formed, and these crystals remain unchanged in their properties under practically any series of temperatures below the melting point of the alloy. Prolonged annealing does not soften it, and it is not hardened by heating it to a high degree and quenching in water. It does not take up carbon to any appreciable degree, even when surrounded by carbonaceous material in a closed vessel for days at a bright orange heat, say 1000° C. or more.

All of the polished alloys, when heated in an open fire, take on a thin film of oxide, which finally terminates in a deep blue-black color. This oxide is so firmly adherent that it absolutely prevents further oxidation of the metal, so that even though the sample may be heated for days at this temperature, it will not show the slightest gain or loss.

Thus far, the lathe tools, surgeons' scaples, and dental instruments are the only forms of stellite which have been placed on the market. It is hoped, however, that other articles will soon be forthcoming. Among these will be table and pocket cutlery.

Table knives made of alloy have been in use for a period of six years, and show not the slightest tarnish. In fact, they retain their original flash and brilliance far better than any known alloy. The wear on these knives is remarkably slow. A teaspoon which was weighed before and after six months' use showed no weighable loss whatsoever. At the rate of wear after one year's service it seems certain that the spoon will last at least a thousand years and still be serviceable.

### Effect of Acids and Alkalis

All of the alloys are attacked by sulphuric, hydrochloric and hydrofluoric acids or by mixtures of the same. They are also attacked by the fused alkalis. As already stated, they change color at a dull red heat, but after once becoming coated with oxide, they undergo no further change and may be maintained for days at 1000° C. without loss or gain in weight. They are practically immune to all organic acids in solution, as well as to all antiseptic solutions, including bichloride of mercury, phosphoric acid, etc. They are likewise unaffected by solutions of the caustic alkalis, and are practically immune to nearly all neutral chemical solutions, including ammonium chloride, which so readily attacks iron and steel.

Table-knife blades made of the alloy remain brilliant and untarnished after years of service. The cutting edge of the table knife wears very well indeed, and from the experience already gained, a set of stellite knives will, if properly taken care of, last at least a generation for ordinary service.

The elastic limit of hammered stellite is not equal to that of tempered steel, but it sufficient for all ordinary requirements. In stiffness it is superior to steel and in fact, to any other alloy or combination in practical use. Table-knife blades can therefore be made quite thin and still be stiff enough for practical purposes.

Kokomo, Ind.

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**Spanish Pyrites in Restricted List.**—Pyrites are included in the list of articles that cannot be imported, except a tonnage not exceeding 125,000 long tons, prior to October 1, 1918. A meeting of the domestic pyrites producers was held in the Council of National Defense Building, Washington, March 11. In order to help out the shipping situation, it was announced that the estimated imports for the next six months would have to be reduced; and the committee appointed to consider this matter recommended that the reduction in imports be made gradually, as follows: April, 40,000 tons; May, 30,000 tons; June, 20,000 tons; July, 15,000 tons; Aug., 10,000 tone; Sept., 10,000 tons. The importance of making up this loss in Spanish pyrites by the increased production of domestic pyrites to the greatest extent possible is made obvious by the above. It is understood that licenses for importing Spanish pyrites loaded after Apr. 15 will be issued only on new applications, in connection with the 125,000 tons of Spanish pyrites allowed for importation between that date and Oct. 1, 1918.

# Some Problems in Evaporation and Drying*

BY P. B. SADTLER AND F. M. DE BEERS

IN OUR work of designing and building evaporators for all kinds of service we are often presented with new operating conditions, new results desired and new chemical engineering problems that are extremely interesting. While we recognize the necessity and importance of a thorough training and knowledge of the theoretical side of this business, we have also been shown that the important thing, so far as the satisfaction of our clients and the advancement of the chemical industry are concerned, is the practical application of these theories usually based upon some previous experience that we have analyzed as far as possible on the basis of these theories.

It often happens that a process will be marked out in a laboratory and the evaporation part of the process will appear to be very definite as regards certain important features, but our analysis of the result will introduce factors that never appeared at all in the laboratory. For example, we had a client who wanted to concentrate a certain solution beyond the saturation point of the salt contained in the same, with the intention of precipitating that salt in the evaporator. The solution was concentrated on a fairly large scale in the laboratory, and the crystals were perfect in form and rather large, somewhat larger than dairy salt, for example.

Our analysis of the problem from a rather practical standpoint led us to believe that, under actual operating conditions on a large scale, the crystals formed would be very small. This was not because all crystals formed in the particular type of evaporator we intended to use are small, as in most cases the crystals are well formed and of a size much larger than we said would be the case with our customer's product. Our reasons for saying the crystals would be small were as follows: The solution itself and the mother liquor, as the crystallization began, were both easy boiling solutions, practically as fluid as water, with no viscosity, and very few impurities present. The specific gravity while high did not give a liquor having the physical qualities of sugar solutions, caustic soda, etc. The salt formed was very heavy. The circulation in the type of equipment used is very rapid. We reasoned that there would be no chance for the crystal to build up, because of the rapid circulation and the molecular weight of the salt formed. The circulation would remove it from the heating or concentrating zone quickly. The solution being very fluid would not tend to keep the crystals in suspension and the tendency to quickly settle out was, of course, assisted by the high molecular weight of the salt itself. In this way the small crystals would separate from the solution circulating through the tubes and there would be no chance of their becoming larger. With a viscous solution and where the salt formed is not very heavy, the crystals stay in suspension until they are large enough to overcome these factors, when they settle out, notwithstanding the rapid circulation. While they are still small, they remain in suspension and are carried through the heating tube repeatedly and build up because of evaporation produced, and become larger with each passage through the tubes, until they are large enough to overcome the effect of viscosity and circulation when they settle out of the path of circulation. This is the case where sodium chloride crystallizes out of a caustic soda solution, or from a glycerine solution.

Referring back to the problem of our clients, we reasoned that the crystal first formed would not be circulated again, and consequently would be small, and we designed our equipment accordingly. Most any form of salt separator can be used where the crystals are large, but with very small crystals many of the more efficient types of separators or filters have to be discarded.

The filters we put in were not as efficient as other types we make, which are suitable for large crystals, but we believed they were the only style to use if small crystals resulted. Fortunately for us our conclusions were correct, as the crystals were exceptionally small—nearly as fine as talcum powder, and if we had followed the laboratory data alone, and used a filter suitable for large crystals, our client would have had no end of trouble, and he probably would have condemned the entire evaporating apparatus.

This is simply an illustration of the value of applying scientific data to any design of evaporator, and the necessity of occasionally disregarding a more efficient type of construction in order to have an equipment that will be commercially satisfactory.

We often have to advise against the use of multiple effect economy, or to limit the number of effects because of certain physical properties of the solution being concentrated or because of the chemical characteristics of materials in solution or suspension. We know, for example, that a certain minimum effective temperature difference is necessary for efficient operation. The capacity in pounds of water evaporated per square foot per hour is directly proportional to this effective temperature difference, which is the difference between the temperature of the vapor or steam being condenssd and the temperature of the vapor formed from the liquid being concentrated—minus the excess boiling temperature of the solution. The capacity is also proportional to the velocity of the vapor on one side of the tube and to the velocity of the solution on the other side.

In most types of evaporators the velocity of the solution is caused by the heating or evaporating of same and the greater the temperature difference the greater the velocity of the solution. In this way the capacity of a tube is greatly reduced, as the temperature difference goes down and the first cost of the evaporator becomes prohibitive, notwithstanding the apparent saving in steam because of the greater number of effects. As the temperature difference and velocity of circulation are reduced, there may be an opportunity for materials to come out of suspension or solution and deposit on the tube, which would not form there if the circulation were better. Any solution that has a tendency to foam will give less trouble with a greater temperature difference per effect, and this may limit the number of effects we can use, although we have found a way to overcome this trouble to a large extent by following a certain scheme of operation. Where a solution has a boiling point above that of water we must have an effective temperature difference above this excess or we will not do any work. This matter of excess boiling

*Abstract of a paper presented at the St. Louis meeting of the American Institute of Chemical Engineers, December, 1917.

temperature often limits the number of effects we can economically use from a commercial standpoint.

It is evident, therefore, that any recommendations we make as to type, number of effects, auxiliaries, etc., must be first based on a complete knowledge of the chemical and physical properties of the solution to be concentrated. We must have the complete confidence of our client, otherwise our work can only be half done. We also believe in explaining our own reasons for every step in the development of the final design, which include reasons based entirely on practical experience with some similar material. I would like to explain in detail some of the problems we have worked out, but in all fairness to our clients I do not feel privileged to refer to specific problems.

The results of our work in every case belong to our client, and no one but that client should know what he is doing.

While we have a large amount of practical data, and while there are a few excellent books on the theoretical side of evaporator design, we have often wanted some conclusive evidence in connection with the determination of certain constants and variables that does not seem to be available anywhere. I am pleased to take this opportunity of announcing that an arrangement has been made between our company and the University of Michigan, whereby we are giving a laboratory to the University, which will co-operate with us in securing fundamental scientific data relating to evaporators. Dean Cooley and Professor Badger, as well as the President of University and the Board of Regents, have co-operated with us to the fullest exent, and within a short time we expect to have some of these factors definitely determined which we now base entirely on practical experience backed by scientific reasoning. All data obtained that is of interest to the scientific world in general will, of course, be published. The establishment of this laboratory should be most valuable to students in chemical engineering, as the first purpose of same is for the benefit of the students, and our own work will only be done when the laboratory is not needed for the student work. The laboratory is housed in the old boiler house of the University, located in the southeast corner of the campus. It occupies half of the building, the evaporators themselves being erected in the boiler room.

This laboratory will be used to work out government problems, also commercial problems of responsible individuals or companies. The main purpose of the plant from our standpoint, however, is to give us a place where we have all the equipment and facilities for the determination of evaporation factors, with all variables eliminated except the one we are working on. We wish to correlate theoretical and practical data and do not intend to repeat the work done by such eminent authorities as Dr. Hausbrand, for example. We intend to use to the fullest extent the results of his work and may later check up certain things, largely to gain the knowledge that is only possible through such experiments. Our equipment is large enough to carry on our experiments on a commercial scale, with the personal error factor very largely eliminated because of the quantities handled. We want our results to be commercially valuable, and among the things we are going to do are the following:

Determination of velocities of steam, vapor and liquor in various standard types of evaporators and under various normal operating conditions.

Value of catchalls of various types.

Amount of loss of liquor by entrainment and by foaming and best means of overcoming same.

Separation of crystals from mother liquor.

Location of non-condensible gases and amount of same from various commercial solutions, also source of same and best means for their removal.

Determination of loss of vapor with efficient removal of these gases.

Determination of volume removed at various stages of the work in a multiple effect, etc.

Conductivity factors in heaters and surface condensers under varying conditions as to velocity, viscosity, size and shape of tube, etc.

Constants based on work done per square foot of heating surface with the following variables:

Effect of velocity of steam or vapor.
Effect of velocity of liquor.
Effect of temperature difference.
Effect of vapor density.
Effect of crystallization.
Effect of scale on tubes.
Effect of temperature of entering liquor.
Effect of materials in suspension.
Effect of materials in solution.
Effect of excess boiling temperature.
Effect of viscosity.
Effect of evaporate type.
Effect of density of liquor.
Effect of tube length and diameter.
Effect of tube depth in a horizontal tube machine.
Effect of downtake area and location of same.
Effect of metal used for heating surface.
Effect of surface of tube on capacity.
Effect of protective coverings.
Effect of moisture in steam.
Effect of hydrostatic head.
Effect of area of liberating surface, etc., etc.

Liquor level regulators and their usefulness.

Determination of effect of heat of solution when concentrating a salt solution.

Best method of regulating size of crystal formed.

These are only some of the things we have planned to do, but this may give you an idea of how the laboratory will be used. We feel we just about know a lot of these things, but want this conclusive confirmation or correction of our own theories, which are now largely substantiated by actual results. We would be very pleased to receive suggestions from members of the Institute as to data that should be obtained as regards general or specific evaporation problems. We expect later to expand the laboratory so it will include drying machinery, filtering and pressing equipment, etc. While we are called upon to work out a good many chemical engineering problems that do not relate to our evaporators, the purposse of this laboratory for the present, at least, is simply to secure evaporation data during such time as it is not needed for student work.

Swenson Evaporator Co.,
Chicago, Ill.

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**Portugal Takes Over Mines During War.**—According to Consul General W. L. Lowrie, Lisbon, a decree of the Portuguese Government dated March 14 reserves to it the sole sale and export of all minerals found in the country that are of value in war industries. The Government, through the Minister of Labor, upon recommendation of the Department of Mines, will fix the prices at which the minerals affected by the decree will be sold. Wolfram and chromium are included in the provisions of the decree, and consequently all exportation of these minerals is prohibited. All stocks at the mines or elsewhere must be declared to the Department of Mines under penalty that the mineral will be seized.

# *Synopsis of Recent Metallurgical and Chemical Literature*

**Aromatic Nitriles by Catalytic Dehydration.**—A new method of preparation of aromatic nitriles in the vapor phase has recently been described by ALPHONSE MAILHE in *Comptes-Rendus, de l'Académie des Sciences*, Jan. 7, 1918, vol. 166, pp. 36-38.

It is known that on treating esters by ammonia, these are converted into amides:

$$R.CO.OR' + NH_3 = R.CONH_2 + R'OH.$$

on the other hand, amides yield nitriles by dehydration in the liquid phase in the presence of phosphoric anhydride or certain catalysts (pumice, sand, alumina, graphite).

$$RCONH_2 = H_2O + RCN.$$

Amides, however, are solid substances with high boiling points and, consequently, difficult to pass over catalysts in the form of vapor. The question arose whether the action of gaseous ammonia ($NH_3$), reacting with esters in the vapor phase in the presence of dehydrating catalysts, could not give the two reactions given above simultaneously and, thus, lead directly to nitriles. This assumption has proved to be correct and has been substantiated by experiments.

On directing methyl benzoate ($C_6H_5.CO_2.CH_3$) vapors together with gaseous $NH_3$ over thoria heated between 450-470 deg. C., a gas is collected consisting of excess $NH_3$ and $H_2$, and a liquid which separates into two layers: the one, aqueous, giving an aldehydic reaction; the other, on being subjected to distillation, yields a small quantity of $CH_3OH$ with a little $CH_2O$ held in solution therein, and another fraction which distills between 181-191 deg. C. Above 191 deg. C. the residue left was insignificant in amount. The portion boiling between 188 and 191 deg. C. possesses a strong odor of bitter almonds. With chloride in hydrochloric acid solution, it gives immediately a crystalline yellow precipitate, pointing to the presence of benzonitrile $C_6H_5.CN$ which boils at 190-191 deg. It has been identified by subjecting it to hydrogenation over reduced nickel at 180-200 deg. C. whereby it is converted into $C_6H_5.CH_3$ and a mixture of benzylamine and dibenzylamine.

As regards the aldehydic reaction pointed out above, it is due to the decomposition of a small amount of methyl alcohol into $H_2$ and formaldehyde:

$$CH_3OH = H_2 + H.COH.$$

It will be seen that the simple decomposition of methyl benzoate by gaseous $NH_3$ in presence of thoria, constitutes an easy method for the production of benzonitrile.

$$C_6H_5CO.OCH_3 + NH_3 = C_6H_5.CN + H_2O + CH_3OH$$

Up to 400 deg. C. this reaction does not take place in an appreciable manner. At about 430-440 deg. C., it is becoming important and, at 470-480 deg. C. it is almost total.

In the case of ethyl benzoate the reaction leads also to benzonitrile.

Toluidic esters behave similarly to benzoic esters, yielding the corresponding toluidic nitriles:

$$C_6H_4<\begin{matrix}CH_3\\CO.OR\end{matrix} + NH_3 = C_6H_4<\begin{matrix}CH_3\\CN\end{matrix} + H_2O + ROH$$

The methyl-ester of ortho-toluidic acid which boils at 207 to 208 deg. C. yields ortho-tolunitrile which boils at 203 deg. C. The ethyl ester of paratoluidic acid leads likewise to paratolunitrile. Phenylacetic acid readily gives ethyl phenylacetate and the latter, when passed in the form of vapors together with $NH_3$ over thoria at 450- to 460 deg. C. yields benzyl cynide $C_6H_5CH_2CH$ By this method which seems to be possessed of a very general character, the use of potassium cyanide is eliminated. The yields of aryl nitriles are said to be good.

**Dimethylaniline by Catalytic Dehydration.**—A new method of preparation of mono-methyl-aniline and dimethylaniline was presented to the French Academy of Sciences by A. Mailhe and F. de Godon and published in *Comptes-Rendus*, 1918, March 18, vol. 166, pp. 476-469.

It is known that dimethylaniline is an intermediate used in the production of a large number of artificial "coal-tar" dyes. Monomethylaniline is less used for this purpose. In modern industrial practice for the preparation of these two bases, aniline is alkylated by means of methanol. $C_6H_5.NH_2$ and $CH_3.OH$ are heated together with HCl or $H_2SO_4$ in autoclaves at 180 deg. C. in the case of monomethyl-aniline, and 230-235 deg. in that of dimethyl-aniline, with increase of pressure to 30-35 atmospheres. Upon termination of the reaction, the reaction mixture in the autoclave is blown out by means of compressed air into a kettle containing caustic soda in order to liberate the base which is driven out by means of steam. This operation is then followed by rectification. By noting also that the mixture of $CH_3.OH$ and $H_2SO_4$ must be prepared in advance, prior to the reaction proper, under special conditions and that the operations of charging and heating the reaction vessels require certain precautions, it will be seen that the "technique" of this reaction is rather complicated.

The reactions of formation of these two secondary and tertiary bases from $CH_3.OH$ and $C_6H_5.NH_2$ may be considered as dehydration reactions:

$$C_6H_5.NH_2 + CH_3.OH = C_6H_5NHCH_3 + H_2O.$$
$$C_6H_5.NH_2 + 2CH_3OH = C_6H_5.N(CH_3)_2 + H_2O$$

The hypothetical consideration that, on subjecting a mixture of aniline and methyl alcohol in the vapor phase to the action of a dehydrating metallic oxide at a suitable temperature and, thus, to make the reaction proceed in the sense indicated by the above equations, has been given substantial proof by experiment.

On directing a mixture of aniline vapors and methyl alcohol vapor over thoria heated between 400 and 450 deg. C., a notable proportion of mono- and dimethylaniline has been obtained. But part of the $C_6H_5.NH_2$ had not been acted upon.

Zirconia, $ZrO_2$, displayed a behavior almost analogous to that of $ThO_2$.

Alumina, $Al_2O_3$, seems to be best adapted for effecting this preparation of the secondary and tertiary bases. On directing over this catalyst a mixture of aniline and a slight excess of methyl alcohol (both in the state of vapor), at once a mixture of monomethyl- and dimethylaniline has been obtained with only insignificant traces of the original aniline. In this reaction a small amount of methanol is destroyed by dehydration with secondary formation of methyl ether.

$$\begin{array}{l} CH_3\boxed{OH} \\ CH_3O\boxed{H} \end{array} \xrightarrow[-\ H_2O]{} \begin{array}{l} CH_3 \\ CH_3 \end{array}\!\!> O$$

The excess of alcohol is condensed with the bases and can be recuperated by rectification of the condensate. When conversion of the aniline-alcohol is complete, the water and alcohol are separated from the free bases by decantation which latter are then subjected to distillation. In this manner a mixture of monomethylated and dimethylated aniline is obtained.

It was of importance to verify whether methylation of monomethyl-aniline could be carried so as to convert it totally into the dimethyl-derivative. For this purpose a mixture of monomethyl-aniline and methyl alcohol was directed in the state of vapor over $Al_2O_3$ heated to 400 to 500 deg. C. The secondary base was converted into tertiary base.

In these operations the alumina assumes after a certain time a yellowish coloration which later darkens to a brownish tint. Its catalytic power is slightly diminished. A simple calcination is sufficient to make it reassume its pure white color as well as its original activity.

The extreme simplicity of the preparation of these two important bases is evident. The manipulations of the raw materials are reduced to a minimum and no longer require the application of high pressures and acids which had a strong corroding effect upon the cast-iron autoclaves. It is true that this inconveniency has since been avoided by using cast-steel autoclaves lined with an acid-proof enamel. Besides, the use of compressed air, sulphuric acid and caustic soda and the driving-out by steam are steps no longer required. Whereas in present-day manufacture aniline must be very pure and contain not more than 0.5 per cent of $H_2O$, the alcohol be free from acetone which, owing to its high volatility, subjects the autoclaves to excessive interior pressures, in the new method the aniline may contain a certain proportion of water without detriment to the yield of the reaction, and the presence of a rather great proportion of $(CH_3)_2CO$ in the alcohol entails no inconveniences.

**Size of Metallic Crystals.**—Dr. G. H. GULLIVER presented a note on grain size before the March meeting of the Institute of Metals (British) in which he observed that there is a fairly widespread belief on insufficient evidence that under favorable conditions the crystal grains in a metallic mass approximate to a uniform size and uniform compact shape. However, a cursory examination of a micrograph shows that there is a large variation in the size of the grain sections—too large, in fact, for the satisfactory employment of a mean if the sections were disconnected quantities, which, of course, they are not. Therefore the real significance of the term "grain size" is "mean granular volume." Dr. Gulliver presents a mathematical treatment of the subject, confining his attention to the relation between the mean volume of a grain and its mean area of section, when the material shows only one kind of structural constituent. With grains of approximately equal volume (varying say plus or minus 10 per cent), and approximately the same compact shape (that is to say, being polyhedrons of from ten to sixteen faces, with a variation of plus or minus 5 per cent among the corresponding diameters), a micrograph containing at least 200 crystalline sections would show a nearly constant number of grain sections, from whatever part of the mass it is obtained. The approximate relation of the two-dimensional grain size to the mean granular volume is shown by the following equation:

$$\text{Average granular volume} = \frac{3}{2}\left(\frac{A}{n}\right)^{\frac{3}{2}}$$

where A is the cross-sectional area of the section under examination, and n is the mean number of grains appearing in that section. Thus the fraction A/n is the area usually called "grain size." As before noted, if the grains are approximately equal and equi-axed, random sections yield a nearly constant grain size. The converse of this statement is not necessarily true, and a constant two-dimensional grain size might only indicate a recurrent form of distribution. A ready means of detecting a gross departure from uniformity is to measure the areas of the grains of a suitable micrograph, and compare the maximum with the mean. The maximum value of this ratio for equi-axed crystals is shown to be 1.7 with a probable plus or minus variation of 20 per cent—roughly, to lie between 1.5 and 2.0. These ratios may usefully be employed as a criterion of uniformity of the grains, and its value in several measured photographs has been found to lie between 3.5 and 5.0, the higher values being obtained after longer periods of annealing. In other words, the grain size was far from uniform, and annealing increased the degree of non-uniformity.

**Manufacture of Crude Sodium Manganate.**—The *Journal of the Chemical, Metallurgical and Mining Society of South Africa* contains a short description of this subject by F. Wartenweiler. A laboratory process was worked up in view of the shortage of easily soluble oxidizers for use in the reduction works of the Rand and crude sodium manganate was found to be an acceptable substitute for the nearly pure potassium permanganate formerly used. The reactions used are either

$$3MnO_2 + 2NaOH = Na_2MnO_4 + Mn_2O_3 + H_2O$$

or

$$2KNO_3 + 2MnO_2 + 4NaOH = 2Na_2MnO_4 + 2KNO_2 + 2H_2O$$

Ferruginous manganese dioxide ore (pyrolusite) from Pretoria furnished the manganese and analyzed about 40 per cent Mn. Commercial caustic soda and potassium nitrate were also used. The combination found most effective in the first equation was 1 part by weight of the 40 per cent manganese ore to 1.44 parts caustic, and 1 part of ore 1.1 part caustic and 0.4 parts nitre for the second. It is necessary to use a large excess over the theoretical requirement of caustic soda; anything less than 110 per cent will give no manganate. The work was carried on in a four-hearth brick muffle-type calcining furnace ordinarily used for calcining acid treated zinc-gold precipitate. No particular difficulty is encountered in producing the material in large quantity. A product containing 28 per cent sodium manganate was made by the first equation as follows: The ore was finely ground in a ball mill and the chemicals well

mixed in 500-pound batches before charging into each one of the four hearths, where the quantity formed a layer about six inches deep. No stirring or rabbling is necessary. The furnace was heated to about 450 deg. C. prior to charging, when the temperature was gradually raised to about 560 deg. C., maintaining this heat for eight hours. The furnace is cooled for four hours before the charge is withdrawn. By the end of the heat the mass has agglomerated into a sticky mass which must be barred loose. As the manganate is slowly and gradually converted on exposure to air to sodium permanganate, manganese carbonate and manganese dioxide, it must be packed in sealed packages. The crude mass, upon coarse crushing, is more soluble than bleaching powder, and is easier to handle and control. When once dissolved and converted to permanganate by dilution with water, it is comparatively stable.

**New Chimney at Tacoma Smelting Company.**—The new stack of the Tacoma Smelting Company at Tacoma, Washington, 571 ft. by 23 ft. 11 in., exceeds by one foot the height of the tallest stack previously in existence—the concrete chimney at Saganoseki, Japan. This new chimney was built as a result of the smoke investigations conducted by the American Smelting and Refining Company (see METALLURGICAL AND CHEMICAL ENGINEERING, Vol. XVII, page 682, Dec. 15, 1917), and supplanted a thirteen-year old concrete chimney, 300 ft. by 21 ft. CHARLES

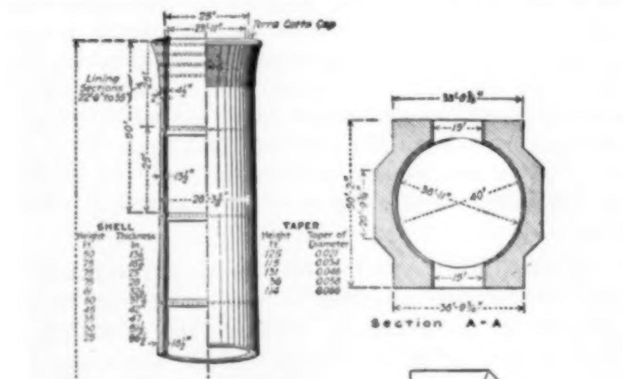



FIG. 1. BASE AND SHELL DETAILS OF TACOMA STACK

E. FOWLER discusses the foundation problems encountered in the construction in *Engineering News-Record*, Vol. 80, page 644 (April 4, 1918). The first foundation excavation was carried about 8 feet below the original surface to a bed of compact sand, but water was encountered in a test pit at a depth of four feet further. Further test pits revealed a strata of hard blue clay lying at from 9 to 30 feet below the first footing. The foundation area was therefore isolated by the construction of long cut-off walls from the surface to this hardpan. As to the foundation itself, three courses were open: First, to risk the uneven settlement on the varying thickness of sand after its drainage; second, to drive concrete piles to the hardpan, or, third, to carry the foundation itself to the hardpan. The third course was adopted, and a reinforced base, as shown in Fig. 1, was designed by R. Bergerson, chief engineer of the Smelting company. The final dimensions of the work are also given in the figure. Throughout the height there is a 4-in. firebrick sectional lining, separated from the shell by a 2-in. air space. A wind velocity of 125 miles an hour, producing a pressure of 78 lb. per sq.ft. in a flat surface was used in the stability calculations. Six-tenths of the projected area of the circular shaft was taken as the effective normal surface. Permissible soil pressure was determined by the formula

$$p = 0.68 a + 0.014 ah$$

where a equals 3 tons per square foot for moist sand, of 5 tons of hard clay; h is the depth of the foundation bed in feet, and p is the allowable soil pressure in tons per square foot. The computed maximum base pressure from the assumed wind in combination with the weight of the stack is 5.01 tons per square foot.

**Potash from Coal-Burning Blast Furnaces.**—Prof. R. A. BERRY and D. N. MCARTHUR present the result of their studies on the question of recovering potash from the coal-burning iron blast furnaces in Scotland, before a joint meeting of the West of Scotland Iron and Steel Institute, and the Society of Chemical Industry. The work is compared with that of Wysor (see METALLURGICAL AND CHEMICAL ENGINEERING, Vol. XVI, page 205, Feb. 15, 1917), and attention called to the fact that the recovery in Scotland is a considerably different problem from that existing in the United States, since the potash content of the ores is not only lower, but coal is used as a fuel in place of coke, which produces a gas heavily laden with tarry matters. Most of the heavy tarry matter is separated in condensers, and in settling carries down considerable dust. The rest of the tarry matter, the ammonia, and most of the remaining fine dust are then caught by the water during the cleaning of the gas in the scrubbers. The spent liquor from the scrubbers, from which the bulk of the tarry matter and the ammonia have been extracted, is usually allowed to waste, although one plant for several years has recovered potassium salts from this by evaporation. On account of the relatively small amount of dust produced, the authors judge the treatment of this liquor to be at present the most likely means of regaining potash. Eight samples of flue dust from coal-fired furnaces were received, containing an average of 8.86 per cent water soluble potash. The total

yearly yield of flue dust from these plants, however, is only 71 tons. These samples of stove dust were analyzed. The yield of this material from coal-fired furnaces is negligible. However, coke-fired furnaces should yield 150 tons of material containing 7.6 per cent of water soluble potash. Samples of tube cleanings from 15 works were received, and while the potash content ranges from only 1 to 2.7 per cent, nearly 15,000 tons of the material is collected yearly. Fifteen works supplied samples of spent liquor which averaged a residue containing 33.5 per cent potash. The authors calculate that 1694 tons of residue could be collected yearly. Owing to the presence of the tarry matter in this liquor, evaporation is retarded, and is a difficult operation, but when the yield of residue amounts to 100 tons per annum, and exhaust steam for evaporation is available, the matter of its recovery is worthy of serious consideration. An evaporating plant would cost about one dollar per gallon daily evaporation; with spare heat the investment would be recovered in a few years, and even if the value of the potash recovered would but pay for the expense, this method would be the best for its disposal. The "pitch" recovered from the gases amounts to about 112 lb. per ton of coal burned, and contains an average of 15 per cent solids, which in turn will analyze 8.8 per cent potash. The burning might be difficult, but probably could be accomplished. A balance computed for one of the co-operating plants showed as follows:

| | | |
|---|---|---|
| Potash charged into furnace per ton of pig produced | | 7.6 lb. |
| Recovered in spent liquor | 1.4 lb. | |
| Recovered in flue and stove dust | 0.04 | |
| Recovered in pitch | 1.7 | |
| Recovered in tube cleanings | 0.2 | |
| Lost in slag | 2.7 | |
| Total accounted for | 6.04 | 6.04 |
| Unaccounted for | | 1.6 lb. |

The total quantity of potash recoverable from the potash-bearing by-products from Scottish blast furnaces (12 companies, including 17 works and 102 furnaces) is as follows:

| | |
|---|---|
| 1,694 tons spent liquor residue @ 33.5% | 567.4 tons $K_2O$ |
| 100 tons flue dust at 8% | 8.0 |
| 11,092 tons pitch ash @ 8% | 885.8 |
| 8,250 tons tube cleaning dust @ 2.5% | 206.0 |
| Total possible | 1,667.2 tons $K_2O$ |

**Motor Oils from Lignite.**—Investigations recently completed in the *K. W. Institut für Kohlen-forschung*, and mentioned in *Rivista Tecnica d'Elettricita*, Feb. 14, 1918, have shown some remarkable results. Braunkohle and similar lignites were treated with diluted sulphuric acid at ordinary temperatures and a viscous mineral oil of golden-yellow color was obtained, amounting in weight to 5 per cent of the coal. If this oil is treated with naphthaline at higher temperatures, in the presence of chloride of aluminum, an oil is obtained which fulfils the same duties as kerosene. By treating lignites with ozone, carbon compounds are obtained which are soluble in water. It is not possible at this time to judge the true and farreaching chemical importance of these discoveries, says the Italian magazine, which seem to produce fatty substances from lignite.

**Carbonization of Illinois Coals.**—In Bulletin 20, Co-operative Coal Mining Series, Illinois State Geological Survey, F. K. Ovitz of the U. S. Bureau of Mines gives the results of experiments on the carbonization of Illinois coals in inclined gas retorts. The summary of results and conclusions follows: Illinois coal mixed with Kentucky coal before charging yields better coke than Illinois coal alone. The coke has a more uniform cell structure, is denser, more homogeneous, and stronger. If all the retorts are charged with the same mixture, uniform operating conditions can be maintained to insure proper carbonization of all the charges. If, however, the coals are used unmixed, the charges of Illinois coal require either a higher temperature or a longer period of carbonization than the charges of Kentucky coal. Coke from Illinois coal alone contained more ash and had more tendency to form clinker than coke from a mixture of Illinois coal and Kentucky coal. The Kentucky coal had a low ash content, and the ash had a high softening temperature; consequently the ash content of the coke from the mixture was decreased, and the softening temperature of the ash was raised. The yield of coke from mixtures was larger than from Illinois coal alone, and increased as the percentage of Kentucky coal was increased. The amount of breeze in the coke made from unmixed Illinois coal was greater than in coke from mixtures. The amount of breeze from mixtures decreased as the amount of Kentucky coal in the mixture was increased. Mixtures gave higher gas yields and consequently enabled greater production of gas with a given equipment than could be obtained from Illinois coal alone. There is a considerable supply of Illinois coal with a sulphur content low enough to permit its use for gas making without operating trouble from sulphur. The more general use of Illinois coal in gas plants deserves careful consideration from gas manufacturers. At many plants in the Central West the cost of producing the gas can be considerably reduced by using either Illinois coal alone or by mixing with it another coal.

**Alternating Current Electrolysis.**—Experiments on this subject are described in the *Journal of Physical Chemistry*, for February, 1918, by Harry B. Weiser. The results of the investigation are summarized by the author as follows:

The efficiency of the electrolytic corrosion of solid metallic electrodes with the alternating current varies so widely with minor differences in the electrode surface that the results of a given set of experiments cannot be reproduced.

The mercury electrode in thiosulphate solution under the influence of the 60 cycle alternating current is reproducible.

The effect of widely varying conditions on the efficiency of electrolytic corrosion with the alternating current of constant frequency has been studied with mercury electrodes in sodium thiosulphate solution.

The efficiency of corrosion increases almost directly as the concentration of thiosulphate solution. With too high a concentration, however, a film of sulphide forms over the electrode which cuts down the corrosion.

The efficiency of corrosion increases with the current density but not in direct proportion. The variation from strict proportionality is greater in dilute than in concentrated solution.

Mechanical stirring increases the efficiency of corrosion.

The efficiency of corrosion decreases with decrease in temperature.

Any variation in conditions that affects the concentration of electrolyte in the immediate region of the electrodes correspondingly affects the efficiency of corrosion.

Under like conditions zinc electrodes corrode much less readily with the alternating current than do mercury electrodes.

The effect on the efficiency produced by variations in current density, stirring, temperature and concentration of thiosulphate solution is of the same character with solid metallic electrodes as with mercury; but with the former these effects are negligibly small compared with that resulting from slight differences in the electrode surface.

# Recent Metallurgical and Chemical Patents

## Zinc and Lead

**Details of the Electrolytic Zinc Process.**—A series of patents have been issued to FREDERICK LAIST and J. O. ELTON of Anaconda, Mont., (assigned to the Anaconda Copper Mining Co.) on certain features of the electrolytic production of zinc.

In order to clear the electrolyte of arsenic and antimony the precipitation of an excess of ferric hydroxide by lime or otherwise is necessary. This carries down nearly all of these elements, probably as ferric arsenate and antimonate. More iron may be required than is dissolved from the leached ore, and while this deficiency may be gained by passing the solution over iron-bearing material, this method is very slow, and the inventors prefer to supply it as follows: Scrap iron or iron ore is heated with 20 per cent sulphuric acid until the solution contains 5 per cent or more iron, when manganese dioxide or any oxidized ore of manganese is added to the hot acid solution, quickly bringing all iron to the ferric condition. A sufficient quantity of this ferric solution is then added to each leach, the iron, with the arsenic and antimony, is precipitated and removed. The manganous salts may be reoxidized in the electrolytic operation and are available for re-use. (1,255,436, Feb. 5, 1918.)

Instead of adding the ferric precipitate (containing a very material quantity of zinc sulphite) to the unroasted ore and subjecting it to a high temperature calcination which not only oxidizes the iron to an insoluble state, which is desirable, but also destroys any sulphates present with the accompanying waste of sulphuric acid, the latter may be avoided by roasting the precipitate in a separate furnace with temperature controlled and less than 625 deg. C. (1,255,438, Feb. 5, 1918.)

Or this precipitate and all other residues containing all the copper, lead, silver, gold and also a material percentage of the zinc of the original ore may be dried, mixed with fine coal, and smelted in a reverberatory furnace. There will result a matte containing most of the copper, silver and gold, a fume consisting principally of oxide of lead and zinc, and a slag which is reasonably free of values. The fume is collected in a bag house or otherwise, and is returned to the leaching plant where it is treated with dilute sulphuric acid. The zinc sulphate solution produced is treated as other like solutions, and the residue containing most of the lead of the original ore may be dried and smelted for lead in the usual manner. (1,255,440, Feb. 5, 1918.)

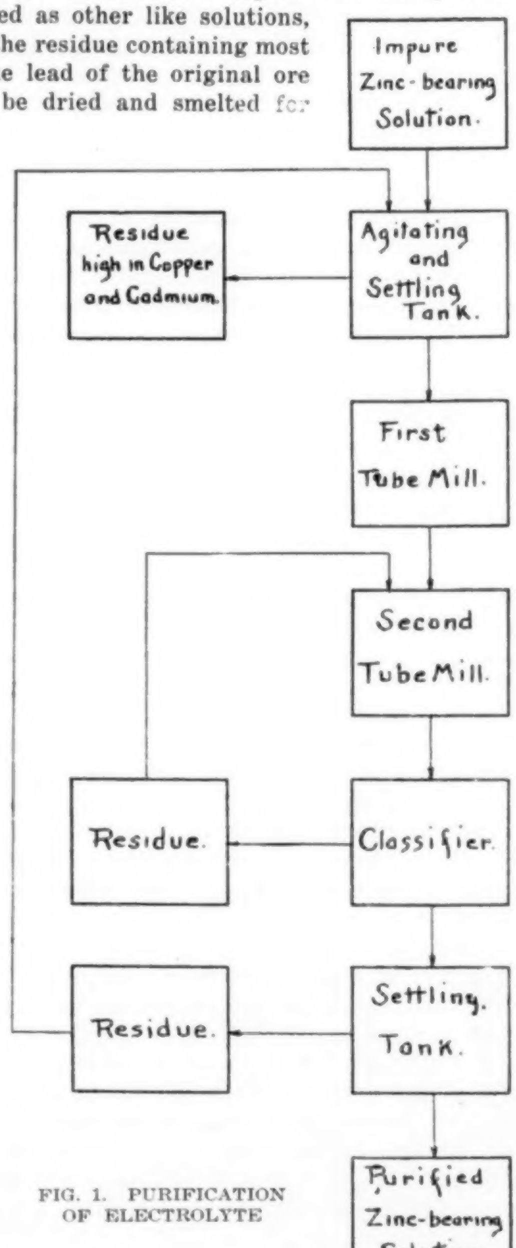


FIG. 1. PURIFICATION OF ELECTROLYTE

Since the precipitation of impurities in the electrolyte ordinarily requires a large excess of zinc, while tube mills with zinc balls necessitate a very slow rate of flow, the inventors patent the process shown in the flow sheet, Fig. 1, wherein the bulk of the copper, cadmium and other electro-negative metals are first precipitated by zinc dust. The clear solution then goes to a pair of tube mills, the first with zinc balls, the second with zinc shot. Thus the purification is effected at a higher rater of speed. (1,255,434, Feb. 5, 1918.)

They further patent another method of purifying solutions of traces of copper and cadmium by the use

of zinc sponge which is more efficient than furnace metal. This sponge is prepared by the electrolytic precipitation from the cold, neutralized, impure solution itself at voltages between 0.5 and 2.3, and current densities between 2 and 30 amp. per sq.cm. Zinc anodes are used, maintaining normal concentrations of the metal. At lower voltages the sponge tends to collect on the bottom of the cell, but it may effectively remain suspended in the solution or attached to the cathode. If the rate of flow of the solution is slow its complete purification may be effected during the passage and the sponge may be available for other portions. A more rapid rate is desirable, so that the overflow carries sufficient sponge to complete its own purification. If the current conditions are properly regulated, little or no zinc is precipitated, the deposit consisting of the more electro-negative impurities. If care is taken to dry the sponge under strictly non-oxidizing conditions it may be used in place of the ordinary zinc dust at a later time. (1,255,435, Feb. 5, 1918.)

The formation of the zinc sponge may advantageously follow a primary purification by metallic zinc, when residual traces of arsenic are eliminated as arsine. For deposition of the purified solution into coherent cathodes, the conditions should preferably be: acidity of 4.5 per cent, temperature of 35 deg. C., voltage from 3 to 4, current density 0.0215 to 0.0323 amperes per square centimeter. (1,255,439, Feb. 5, 1918.)

Difficulty in making a coherent deposit depends not only upon the purity of the electrolyte, but upon the cathode as well, which must be highly electro-positive. Thus, pure aluminium is quite suitable, but aluminium containing 5 per cent of copper will often take no deposit, while 1 to 2 per cent copper will scarcely deposit after it has been stripped a few times. Aluminium bronze may be made to take a good deposit if the alloying metals be removed by nitric acid, and the resulting film of alumina removed. After a few deposits, however, when the pure aluminium surface thus prepared becomes contaminated or worn, a retreatment is necessary. The more electro-negative impurities in the cathode sheet are thought to form couples with the deposited zinc, greatly increasing the rate of solution and therefore cutting down the current efficiency. Laist & Elton therefore patent the use of a pure electro-positive cathode. (1,255,433, Feb. 5, 1918.)

Since the ill effects of a small impurity on the electrodeposition persist for days after the inflowing solution is restored to normal, the inventors equip a test cell with electrodes similar to those employed in the main system, and so place this cell as to receive a continuous portion of the purified solution passing to the storage tanks from which the main electrolytic cells receive their supply. The current and other conditions in this indicator cell being maintained as in the main cells, the quality of the deposit and the current efficiency serve as an accurate indication of the purity of the electrolyte. In case any portion of the solution falls below the standard of purity, this part can be re-purified before entering the main cell room. (1,255,437, Feb. 5, 1918.)

**Treatment of Zinc-Lead Fume.**—C. C. NITCHIE, of Depue, Ill. (assigned to the New Jersey Zinc Co.), proposes the mixing of zinc-lead fume with sufficient ammonium sulphate to transform all other metallic compounds contained into the corresponding sulphates. The reactions are of the following type:

$$ZnO \times (NH_4)_2SO_4 = ZnSO_4 \times 2NH_3 + H_2O$$

The mixture is heated in a suitable muffle; the reaction commences at about 225 deg. C, and proceeds rapidly at 300 to 350 deg. The escaping ammonia is recovered for reuse. After the reaction the temperature is raised to about 625 deg. C, to expel arsenic and to render iron sulphates insoluble. Water leaching will now produce a residue containing most of the lead, silver, gold, iron, and silica and but little copper and zinc, and can be easily smelted in a lead blast furnace. The solution contains most of the copper and zinc, and but little of the other impurities. It can be purified and electrolysed; or it may be evaporated and the lead-free salt retorted in the usual way. Or finally, it may be precipitated as a basic compound by the addition of ammonium carbonate, with the formation of the corresponding amount of ammonium sulphate for reuse in the early part of the process. (1,258,934, March 12, 1918.)

**Zinc Chloride from Zinc-bearing Ores.**—FRANK K. CAMERON and others of Salt Lake City, Utah (assigned to American Smelting and Refining Company), patent the process of mixing an oxidized or roasted complex ore with a slight excess of 30 per cent HCl, heating the mixture slowly at first to drive off $CO_2$ and other gases, then quickly to complete dessication, and finally for a sufficient time at about 300 deg. C. to complete the evolution of acid gas. Thus iron, manganese, aluminium, silicon and magnesium are converted into insoluble oxides, and after lixiviation the solution will carry practically all of the zinc as chloride. It also contains calcium and lead chlorides, which are removed by precipitation with zinc sulphate. Iron and aluminium may be removed by known methods, or the solution purified as noted in the following patent. (1,261,695, April 2, 1918.) As an alternate process, the ore, pulverized to 100 mesh, is mixed dry with sodium or calcium chloride containing sufficient chlorine to combine with the metallic bases. Distillation in an iron retort will volatilize lead, silver and gold chlorides, and transform the zinc into a basic chloride which is retained in the residue. The residue is then leached in hot water acidified with HCl. In case there is much separation of gelatinous silica, evaporation to dryness may be necessary, followed by an additional leaching. The zinc chloride may be precipitated as a solid halide of sodium, potassium or ammonium by adding the desired alkali chloride to the solution. This salt may be further purified by recrystallization, and may be then decomposed with strong hydrochloric acid. (1,261,696, April 2, 1918.)

**Production of a Superior Zinc-Lead Pigment.**—J. A. SINGMASTER and F. G. BREYER of Palmerton, Pa., (assigned to New Jersey Zinc Co.) have ascertained by an examination of various fractions produced in the process of zinc-burning, that those fractions having a good body or oil absorbing capacity and hiding

power, and which were not overheated, showed a higher ratio of sulphur to lead than similar pigments of a pronounced pink tint. Overheating the pigment substitutes a yellowish tint for the pink, and furthermore granulates the fume. They therefore patent the process and method of burning a zinc-bearing substance in a pigment furnace—such as the blast-furnace type or of the Wetherill grate-furnace type—volatilizing the zinc and lead from the charge, immediately oxidizing the same in a sulphatizing atmosphere, and quickly removing the fume from the region of high temperature. The sulphatizing atmosphere may be obtained by mixing a sufficient quantity of sulphur bearing ores with the oxide, by interrupting the preliminary roasting operation at that point where sufficient sulphur will remain in the calcine, by adding elemental sulphur, or by dropping sulphuric acid into the furnace. The ratio of sulphur to lead oxide necessary to make the improved pigment may lie between one-half and four-thirds, but preferably is about five-sixths. In any case, it is important that the sulphatizing compounds be of such a nature, and be added in such a way that they will furnish the required amount of sulphate throughout the entire evolution of the metal. (1,257,136, Feb. 19, 1918.)

**Recovering Zinc from Slags.**—HERMAN WITTEBORG of Caldwell, Idaho, patents the arrangement of recovering zinc from slags as follows: He causes the slag to flow through a succession of long, narrow, reverberatory furnaces in a thin sheet, where it is superheated by an oxidizing flame, and possibly stirred by a hot air blast. Lime to substitute as a base, and carbon for reduction purposes, may be added to the slag at the outset. The resulting furnace gases are collected and the metallic oxides condensed and separated. (1,250,261, Dec. 18, 1917.)

**Removing Cadmium from Zinc Ores.**—CHARLES P. FISKE, of Palmerton, Pa., (assigned to New Jersey Zinc Co.) patents the application of an ordinary Brückner furnace to the method of eliminating cadmium from zinc calcines already covered in Patent No. 1,161,885 (see METALLURGICAL AND CHEMICAL ENGINEERING, Vol. XIV, page 220, Feb. 15, 1916). This process consists of heating the calcine in a reducing atmosphere at temperatures ranging from 700 to 850 deg. C., wherein the cadmium is eliminated. In the later invention the reducing atmosphere is maintained by the admission of producer gas into the firebox opposite the flue connecting to the roasting cylinder. (1,246,576, Nov. 13, 1917.)

**Composition for Retorts.**—J. D. HOLLINGSWORTH and JOHN MITCHEM of Kusa, Oklahoma, have discovered that zinc retorts of the following composition have a life of up to sixty days when working on Western ores, as compared to twenty days if made of the ordinary mixtures. They dry-mix 36 lb. of St. Louis fire clay with 59 lb. of fire clay cement (hard burned clay ground to a powder) and 14 lb. of "cc" or "g" grade graphite, and then pug this mixture with a solution containing 25 per cent by weight of common salt. The resulting dough is allowed to stand for 24 hr., then molded to shape in a hydraulic press, and dry-heated at approximately 120 deg. F. for from 15 to 20 days. The dried retort is gradually preheated before use. (1,249,960, Dec. 11, 1917.)

## Determining Loss Due to Low Carbon Dioxide

THE accompanying useful chart has been developed by the Uehling Instrument Co., 71 Broadway, New York. It is of unusual interest and value at the present time when the coal problem is so important, for it enables anyone to quickly and closely estimate the money now being lost up almost any chimney due to low $CO_2$.

Simply connect the percentage of $CO_2$ (shown in column C) with the money now being spent per year for coal, (shown in column A) and the intersection of the connecting line with column B immediately gives the amount using from the chimney in the form of heated gases.

The object of this chart is to show that a high percentage of $CO_2$ is most desirable. Even where the $CO_2$ is as high as 21 per cent, the theoretical maximum there is a loss because in the average power plant the flue gases leaving the boiler have a temperature as high as 500 or 600° F. Loss therefore is inevitable unless a blower is used for exhausting the gases and some sort of interchange system is installed for either heating the feed water or preheating air and leading it under the grate.

It is significant that most of the large power plants

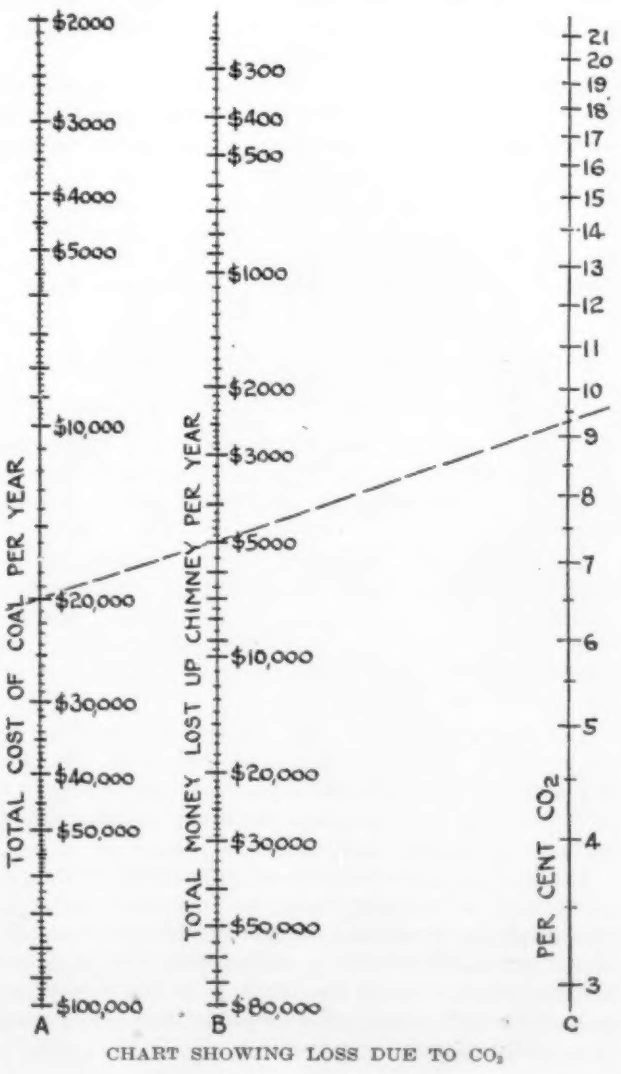



CHART SHOWING LOSS DUE TO $CO_2$

of today have adopted $CO_2$ instruments that record automatically and continuously. The reason for this is to keep constant tab on the workers in the boiler room and the efficiency of combustion. The recorder may be placed at any convenient distance from the boiler in the office of the chief engineer, owner, manager or superintendent, while an auxiliary $CO_2$ indicator is placed on the boiler front in full view of the fireman. The function of the indicator is to keep the fireman constantly informed as to the efficiency of his own work. This feature is most commendable.

Coal cannot be saved by a $CO_2$ machine alone. If no attention is paid to the indicator or recorder, the installation of such apparatus is useless. The records should be carefully watched and studied and adjustments should constantly be made in firing methods until the best percentage of $CO_2$ is obtained. After the best mark is reached, fluctuation of the $CO_2$ line below that mark to any great extent should not be allowed.

This chart is based on a flue gas temperature of 600 degrees F., and an outside air temperature of 60 degrees F. Where the flue gas temperature is higher, or the outside air temperature lower, the money loss will be correspondingly increased. On the other hand, with a higher outside air temperature and a lower flue gas temperature, the money loss is proportionatly decreased. Further, in the construction of this chart, it has been assumed that the coal has a calorific value of 14,500 B.t.u. per lb. of combustible.

It may also be interesting to point out that where there is only 3 per cent of $CO_2$ in the flue gases, 76 per cent of the heat value of the coal passes up the chimney as waste under the conditions outlined above. It is impossible, however, for these gases to contain as low as 2 per cent, because it would require more than the original quantity of heat in the coal to heat the enormous surplus of air to a temperature of 600 degrees F.

## A New Pressure Governor for Gas and Liquid Systems.

IN MANY power installations, where air, other gases or liquids must be maintained under pressure, the demand for an automatic method of doing this has arisen.

As a result the General Electric Company has developed a new pressure governor to control standard self-starters for motor operated pumps and compressors. The governor maintains a pressure between predetermined limits on any gas or liquid systems that will not corrode the Bourdon Tube.

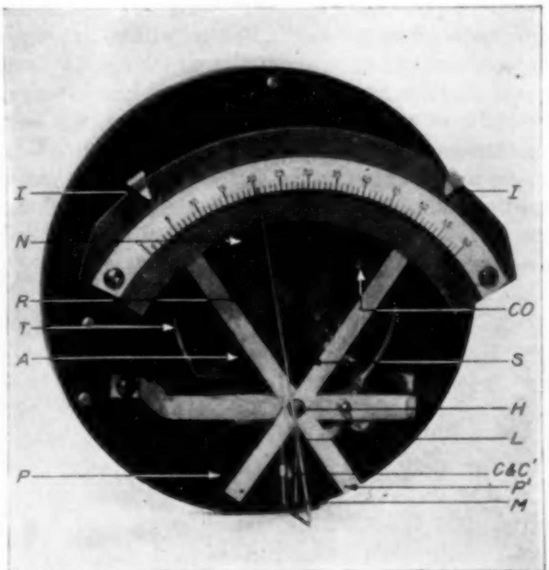
The governor can be used on any standard a.c. or d.c. circuit. It is rated for pressures of 80, 100, 160, 300 or 500 lb. and operates within settings of from 3 to 12 lb. between high and low pressures. Governors for higher pressure are also made.

The governor shown in the accompanying illustration consists of a Bourdon Tube, an indicating needle, a graduated pressure scale, adjustable high and low pressure stops to determine the desired pressure range and a relay which actuates the contacts in the control circuit of the self-starter, all enclosed within a dust proof case, easily opened for inspection.

Action of the governor is dependent on the Bourdon Tube which should be connected to an independent discharge pipe from the pressure tank. The free end of the tube T is mechanically connected to the indicator needle N moving it over the scale as changes of pressure affect the tube.

After the settings for the pressure range have been made, the governor will automatically maintain pressure within those limits. The operation of the pressure governor is as follows:

Assuming that the pressure is at the low value, as indicated by the left-hand indicator I, the contact C on the needle N completes the circuit through the contact C′ on the movable arm M, which at the low pressure points rests against the stop P′. When this contact is




THE INTERNAL MECHANISM FOR A CR 2922 PRESSURE GOVERNOR

made, the circuit is completed through the relay coil R, causing the armature A to close. Attached to this is the contact CO which upon closing, completes the control circuit to the self-starter, causing the motor to start.

The armature is also attached to the spring S which holds the contact C′ firmly against C until contact is broken at P.

As the pressure increases, the needle pointer moves to the right, but its lower part to which the contact C is attached moves to the left, and is followed by the movable arm M. When the high pressure point is reached, the movable arm is prevented from traveling further by stop P and the needle continues its course, breaking the circuit by separating contacts C and C′. The instant the circuit is broken, the relay R is deenergized, its armature falls, releasing the tension of the spring S and because the movable arm M is counterweighted it returns to the stop post P′.

When the pressure is decreased to the minimum value, the contact C again completes the relay coil circuit by engaging contact C′ and the cycle of operation is repeated.

The case is tapped and drilled at the bottom for the pressure pipe and electrical conduit connections.

## An Automatic Acid Elevator

AN AUTOMATIC device employing air pressure for blowing acids to higher levels has been developed by the Monarch Manufacturing Works, of Phila., Pa. A patent on the device has been applied for. Fig. 1 is a diagram of the device connected to an acid egg, and Fig. 2 shows the interior construction.

The liquid (acid) flows from low-level tank through the combination check valve and air device into the blow-case. An exhaust check valve EC is placed in the exhaust line, through which air displaced by the in-flowing acid escapes. This exhaust line may be carried back to the filling tank or elsewhere. As the blow-case becomes full of acid, the surging effect created underneath the air valve within the air device proper tends to unseat the air valve (plug), thus allowing compressed air to escape from ports C.A.P. (Fig. 2). This air being under high pressure kicks the air valve up against the under side of the inverted cup-shaped check, carrying both up until the top of the liquid check engages with seat S, thus preventing inflow of liquid or escape of compressed air back to the filling tank. The pressure of the air then acts on top of the liquid within the blow-case, forcing it out the discharge pipe, which as usual, is carried almost to the bottom of the case.

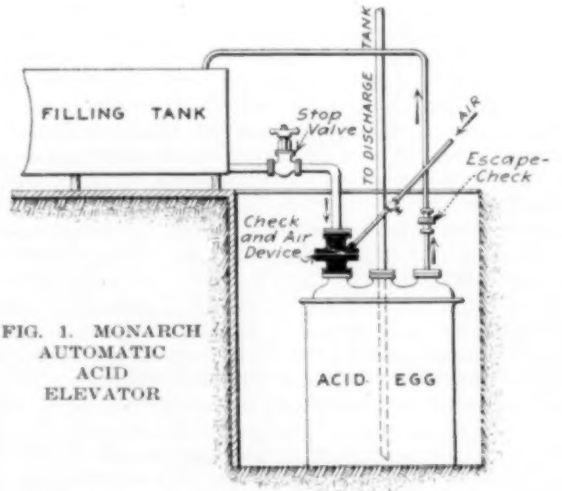



FIG. 1. MONARCH AUTOMATIC ACID ELEVATOR

When all the acid has been discharged, there is a sudden rush of air through the discharge pipe, which relieves the pressure within the case, because the area of the air ports C.A.P. is very much smaller than the area of the discharge pipe. The pressure of the air within the blow-case having dropped to practically nothing, allows the air valve and liquid check to fall back into position, the former shutting off the air ports and the latter permitting the re-filling of he blow-case.

The exhaust air check valve EC allows air under low-pressure (exhaust air displaced by the inflowing liquid) to pass, but when the blow-case is filled, a column of liquid rises in the pipe underneath the check EC, and when air pressure is turned on through operation of the automatic air device proper this column of liquid, under pressure, forces the exhaust air check shut, in which position it remains until the blow-case has been emptied and pressure relieved therefrom, as previously explained, when it again opens for escape of displaced air.

By use of this automatic device compressed air is saved to a considerable extent, for the reason that the air is turned off almost instantly the blow-case is emptied, whereas in the hand operated blow-cases, the attendant of course cannot know exactly when the case is empty, and usually his attention is required by another case or elsewhere, so that it would not be possible for him to turn off the air even though he could know exactly when the case was empty.

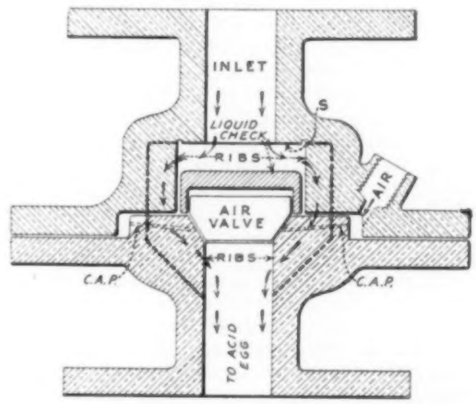



FIG. 2. AUTOMATIC ACID VALVE

## New Lamp Screen for Industrial Lighting

A new article for improving industrial lighting has been placed upon the market by the Laco-Philips Co., 131 Hudson St., New York. It is called laco-dalite and consists of a special blue-glass screen that is clamped over the bottom of the electric light reflector, thus inclosing the bulb. The light thus filtered through the special blue glass, it is claimed by the manufacturers, is equal to that obtained from the nitrogen lamp. It is white and pure and the equivalent of daylight. The question of proper lighting is important in concentrators, especially for table work at night. Both here and in the draughting room as well as in other places a device of this sort should prove helpful.

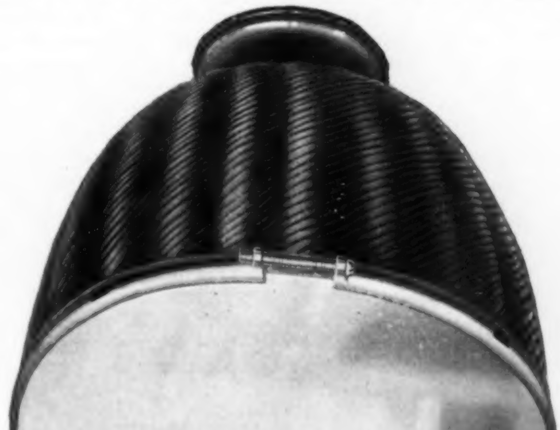


FIG. 1. SCREEN AND COVERING FOR INDUSTRIAL LIGHTING

# Book Reviews

MODERN INORGANIC CHEMISTRY. By *J. W. Mellor*, D. Sc. New edition, crown 8 vo. (13 x 19 cm.), 903 pages, 334 Illustrations. Price $2.50, 7/6. New York and London: Longmans, Green and Co.

The author is well-known for his books on chemical statics and dynamics, and higher mathematics for students of chemistry and physics. In this hand-book for students, and chemists in general, he discusses all the varied phenomena of chemistry, from the simplest to some of the most complex, and after presentation of the facts he draws the evident, or probable, or possible, conclusions as to the theoretical explanation—the *why* and the *wherefore*. Working through this book must be a great exercise in chemical philosophy to the student—a training of his wits, a systematic strengthening of his reasoning powers, an introduction to a higher level of chemical understanding. It cannot but whet the student's appetite for more, and inspire him to higher chemical ambitions. All this can be done by a chemical textbook—when it is written skilfully by a master chemist.

* * *

COAL GAS RESIDUALS. By *Frederick H. Wagner*. 244 pages, illustrated with working diagrams. Price $2.50. New York: McGraw-Hill Book Company, Inc.

In view of the great importance of the by-products of coal to modern industry, especially in its present belligerent phase, it is remarkable that so few books have been written on the subject. One of the few is the volume entitled "Coal Gas Residuals" by Frederick H. Wagner, a second edition of which has recently been issued. This new edition is in many respects a considerable improvement over the first. Information bearing on the uses of the various products in the war has been added that will interest the gas-plant operator who desires a rapid and non-technical summary showing the ultimate useful products derived from the raw materials which he is engaged in producing. The additions include a description of the manufacture of nitric acid from ammonia which has been so important to the German military machine, and a rather hurried resumé of the more important coal tar derivatives and the processes by which they are made. The author has hardly gone far enough in emphasizing the absolute necessity of such products as ammonia, nitric acid, ammonium nitrate, phenol, picric acid, aniline, toluene and trinitrotoluene to a nation at war. In view of the importance that the author attaches to spent oxide as a raw material for sulphuric acid, the chapter on this subject is disappointing because it consists merely in a brief description of the well known processes without even mentioning the peculiar disadvantages of spent oxide and the means that may be employed for overcoming them.

The technical interest and the popular value of the book would be much enhanced if the author had dealt with the important subjects of gas treatment, tar extraction and ammonia recovery from an impartial standpoint instead of being so obviously biased by the theories of the late Dr. Walther Feld. Of many of the Feld ideas, particularly the celebrated series of differential washers so beautifully ideal or ideally beautiful on paper, and so utterly impossible in practice—it may be deeply regretted here in America that they were not at once seized upon and universally adopted *in Germany*, for thereby the downfall of the Kaiser would have been materially accelerated. "As no tar separating plants of the Feld system have as yet been erected in the United States, statements showing results obtained in this branch of by-product recovery will necessarily have to be confined to European practice." The unconsciously pathetic retention of this sentence in the second edition tells its own story. However, frank exploitation does less harm than disguised partiality and Mr. Wagner may be admired for the constancy of his rather lonesome discipleship.

The principal value of the book will be to those who desire a description of the various by-products of coal and the methods and apparatus used in handling them without too many technical details. The descriptions are well written and usually carefully illustrated. The appendix contains a number of tables which the gas engineer and chemist will appreciate, particularly a table of constants for certain gases and vapors. The engineer who desires to obtain a general knowledge of the various systems of ammonia-recovery practiced in Europe will be attracted to the chapter on ammonia, although American practice has contradicted many of the comparative statements given. The Koppers system of benzol recovery and purification is discussed in interesting detail following the outlines of Puening's description.

# Personal

AT THE ANNUAL MEETING OF THE CHEMISTS CLUB of New York the following officers were elected to serve for the following year: President, Ellwood Hendrick; vice-president, Charles H. Herty; non-resident vice-president, Charles L. Parsons; secretary, John R. MacPherson Klotz; treasurer, Henry M. Toch; two trustees to serve for three years, Thomas R. Dunning and Kenneth C. McKenzie.

Mr. C. G. ATWATER, manager of the agricultural department of the Barrett Co., has taken up active duties with the Ordnance Department as consulting engineer in connection with the government nitrate plant.

Mr. H. FOSTER BAIN has been appointed assistant director of the U. S. Bureau of Mines and is in the office of the bureau at Washington.

Mr. D. J. COFFEY, formerly of the Schumacher Mill at Porcupine, has been promoted from mill superintendent to general manager of the Lake Shore properties, situated near Cobalt, Ontario, succeeding John W. Morrison.

Mr. FRED B. CROSBY has resigned his position in the power and mining department of the General Electric Co., Schenectady, N. Y., to become electrical engineer of the Morgan Construction Co., Worcester, Mass. Mr. Crosby has specialized in electrical equipment for steel works.

Mr. JOHN M. ECKERT, assistant engineer in the gas and oils department of Underwriters' Laboratories, has entered the Ordnance Department, U. S. A., as supervisor of Tests at steel plants in the vicinity of Chicago and also in Ohio, Indiana, Wisconsin and adjoining states. Physical tests, chemical analysis, heat treatment at plants and the instruction of inspectors for this territory will come under Mr. Eckert's direction.

Dr. RUDOLPH GAHL has resigned from the position of metallurgist, in charge of concentrator, at the Inspiration Consolidated Copper Co., Miami, Arizona, to devote his time to consultation practice. GUY H. RUGGLES, formerly mill superintendent for the Humboldt plant of the Consolidated Arizona Smelting plant will succeed Dr. Gahl.

Mr. N. J. GEBERT, director of the metallurgical laboratory, Standard Roller Bearing Division of Marlin-Rockwell Corporation, has resigned his position and joined the staff of Mr. Herman A. Holz, New York. Mr. Gebert will be in charge of the metallurgical and magnetic laboratory which Mr. Holz is equipping in the Metropolitan Tower, New York City.

Mr. JUSTICE GRUGAN has discontinued his mining engineering office at 30 Church Street, to assume the duties of chief engineer for Suffern Company, 135 Broadway, New York.

Mr. E. H. HAMILTON, formerly metallurgical manager of the Trail Smelter of the Consolidated Mining and Smelting Company of Canada, has been made smelter superintendent of the Midvale, Utah, plant of the United States Smelting Company to succeed Mr. L. D. ANDERSON, who was appointed manager of the same plant some time since.

Dr. A. W. HOMBERGER, head of the chemistry department of Wesleyan University, leaves this college after the end of the Spring work and goes to the University of Louisville, Kentucky, to be dean of the chemistry department at that place. Dr. Homberger has been at Wesleyan for seven years.

Mr. ARTHUR HOUGH, consulting chemical and explosives engineer, has joined the staff of the Durion Castings Company in a consulting capacity. Mr. Hough for a number of years past has been engaged in the manufacture of acids and explosives of a general character, and has devoted a great deal of time to the development of products such as trinitro toluol, trinitro benzol, and ethylene glycol for the preparation of dinitro glycol, chlorhydrin for the preparation of mustard gas and monochlor benzol.

Mr. M. T. LOTHROP has been appointed assistant factory manager of the Timken Roller Bearing Company of Canton, Ohio. For the past seven years he has been metallurgist for the company and has also been in charge of the steel and tube departments.

Mr. R. B. MOORE, in charge of the Golden, Colorado, station of the Bureau of Mines, has been visiting Eastern cities in connection with Government business.

Mr. JACQUES S. NEGRU, mining engineer of Denver, Colorado, has enlisted with the Canadian forces and has gone to Winnipeg to be detailed to the Engineers Corps. on Railway work.

Mr. W. C. POTTER, formerly with the A. S. & R. Co., in Mexico, has been appointed head of the Equipment Division of the Signal Corps in charge of production of airplanes and motors for the army.

Mr. J. M. RIORDAN, until recently sales engineer of the Grant Lees Gear Company of Cleveland and formerly representing the Fellows Gear Shaper Company of Springfield, Vermont, in the Central States, is now connected with the sales organization of the Cleveland Milling Machine Company, 18511 Euclid Avenue, Cleveland, Ohio.

Mr. ALBERT TATE SMITH, lately manager of the R. U. V. Company, 50 Broad Street, New York City, has returned to the Permutit Company, with which he was formerly connected, to take the position of assistant manager of sales.

Mr. WILLIAM W. TORRENCE, formerly of the General Electric Company, has been appointed general manager of the Denver Engineering Works Company, succeeding Mr. Lewis Searing, who has resigned.

Mr. H. G. WEIDENTHAL, formerly works manager of the General Steel Company, Milwaukee, Wis., has joined the forces of James H. Herron, Cleveland, Ohio, in the department of steel works design and operation. Mr. Weidenthal will give special attention to electric steel making furnace operation.

Mr. FRED D. WILLIAMS, head of the power specialties department of the H. W. Johns-Manville Co., severed his connection with that company and went to the L. H. Gilmer Co., on April 29, as assistant general manager of the combined properties of that corporation, with headquarters at Tacony, Philadelphia.

Mr. WM. WRAITH, of the International Smelting Co., has been elected president of the Utah Section of the American Institute of Mining Engineers, Walter Fitch of the Chief Consolidated Mining Company vice-president, and F. G. Moses, of the Utah Station of the U. S. Bureau of Mines secretary, at the annual meeting held in Salt Lake City recently.

# Current Market Reports

## Non-Ferrous Metal Market

*Wednesday, May 8.*—There is nothing much to report on lead or spelter. The price of tin has advanced.

*Copper.*—The British government is now making big demands on the producers, who anticipate difficulty in meeting the requirements for copper in May. The copper producers have been in session with the price-fixing committee of the War Industries Board.

*Tin.*—The London tin market jumped £20 per ton and our market has become unsettled for any business until buyers can see more clearly the reason for this advance. The price in London is £360. Spot tin, Straits tin or Standard tin is not available.

*Lead.*—The lead position remains quiet and without special feature. The Trust price is 7c. per pound with independents quoting slightly above.

*Spelter.*—The spelter market continues dull. A little more business is recorded and prices are quoted around 7c. per pound.

*Antimony.*—A little more business is reported during the past week. The spot market price for antimony regulus is 13c. per pound, with shipments from the Far East quoted at 12½c., duty paid.

*Tungsten.*—A fair volume of business was done. The prices remain unchanged at $24.00 for high-grade wolframite and $24.50 for high-grade scheelite, although the latter is not so much in demand for immediate delivery as it is for future delivery. In view of the high freight and expense of shipping, the foreign shippers see, if possible, that no material under 60 per cent is shipped to this country.

*Manganese.*—The Government is contemplating the enactment of regulations whereby a maximum price will be established for domestic manganese ore. Shortage of high-grade ore becomes more and more acute and an increase in schedule price is expected.

*Chrome.*—Unchanged at $1.50 per unit for 45 per cent grade. Owing to the shipping situation, shipments of foreign chrome ore have virtually ceased. The few thousand tons that happen to be afloat and unsold have fetched as high as $100 per ton. The market for domestic ore is still chaotic, as it has been during the last year.

### OTHER METALS

| | |
|---|---|
| Aluminum, lb., 98-99 per cent., virgin, Government price | .32 |
| Bismuth, lb | 2.50–2.75 |
| Cadmium, lb | 1.40 |
| Nickel, electrolytic, lb | .40 |
| Silver, oz | 1.00 |
| Platinum, oz | 108.00 |
| Palladium, oz | 150.00 |
| Cobalt, lb | 3.25–3.50 |
| Magnesium, lb | 2.00 |
| Quicksilver, Cal | 125.0 |
| Quicksilver, Mexican | 118.00 |

## The Iron and Steel Market

Steel manufacturers have been revising their rolling and shipping schedules to conform to the new requirements of the Washington authorities. The revision, which has been in progress for several weeks, is along two lines: (1) For the diversion of the maximum possible tonnage to government orders, known as classes I and II and representing war material required by the Government and by its allies; (2) A distribution of the remaining steel to the lines of consumption where it will do most good in helping to win the war.

As to the diversion of more steel to direct war orders, an impetus was given to the changes already in progress by the developments at the meeting held in New York, April 26, between J. Leonard Replogle, Director of Steel Supplies under the War Industries Board, and about fifty representative manufacturers. The meeting was held in the office of President Gary of the American Iron and Steel Institute, and the president submitted a pledge, afterwards circulated to all producers, that they should make a maximum effort to furnish all possible steel for the government requirements. The situation was that the War Industries Board had considered the taking over of all steel shipments, and had indeed drawn up an order to that effect, but by reason of the understanding reached at the meeting Mr. Replogle undertook to see that the order was held in abeyance. The War Industries Board does not desire to take over the distribution of the so-called "commercial" steel unless such action proves necessary, and much prefers that the steel producers make the distribution of steel themselves. In this distribution it will furnish all the aid and advice possible. The board has already made known that among the commercial uses, coming after direct government orders, the highest classifications should be steel for the development of oil production and the transport of oil, and steel involved in agricultural pursuits. This decision helps the steel trade considerably but makes only a beginning in the almost infinite number of gradations from

the most essential to the least essential lines of steel consumption. Of sacrifices for the war there is no end, and one sacrifice is that of diction, since in normal times the word "essential" is hardly used in the comparative degree.

### War Steel Requirements

The shipbuilding operation calls for much more steel than was estimated by producers, even quite recently. In the first place, vessel completions have been steadily increasing, being in the first fortnight of May at the rate of more than 4,000,000 tons deadweight per annum, representing at least 2,000,000 gross tons of steel. In the second place, vessel launchings are at a greater rate than vessel completions. In the third place, keels laid are at a greater rate than launchings, as they represent prospective completions of several months hence. Finally, it is desired to accumulate fabricated parts at shipyards and steel for fabricating at the various fabricating plants, both for the purpose of facilitating the current work and for the purpose of accumulating a reserve against contingencies, including the possibility of traffic difficulties next winter.

Shell steel requirements have been increasing rapidly, as forging capacity has been increased. The forging capacity has been quite below the capacity of the shell making factories, but the shortage has now been eliminated entirely, except as to shells 6-inch and larger, and that situation is expected shortly to be righted.

Structural requirements have been increasing, and there is even a statement that the government requirements in fitted structural work exceed by 20 per cent the average amount of fabricating work done in the past three years, for commercial purposes.

Orders for approximately 100,000 freight cars have been placed, involving more than 1,000,000 gross tons of steel, including plates, shapes, bars, wheels, etc. The cars are to be built according to the original plans, involving substantially the usual employment of steel, except that the inside roof is used on box cars, involving about 400 pounds per car of galvanized sheets, instead of the more modern all-steel construction involving more than double as much. The War Industries Board requires, however, that the Railroad Administration accept Bessemer steel in plates, etc., when it is more convenient for the mills to furnish Bessemer than open-hearth.

Bessemer steel is also to be used for rails, in all probability. Reports from Washington relating to prospective "orders" for Bessemer rails are somewhat misleading. The railroads have a large tonnage of rails now on order at the mills. There will be only very limited tonnages ordered afresh, but it will probably be required that on many of the orders on books, originally entered for open-hearth steel, Bessemer will be required instead. On account of the two $5 a ton advances that occurred in 1916, and the long delays in filling old orders, the orders now on books are for Bessemer rails at $28, $33 and $38 and for open-hearth rails at $30, $35 and $40.

### Commercial Market Remains

Reports that there is no commercial market for steel are an exaggeration, for effect. The large mills as a rule are adhering to former practice and as shipments are made to regular commercial customers they enter additional tonnages for them, but with absolutely no promise, or even intimation, as to the probable time of delivery. Shipments on old orders are to be made, as already indicated, in accordance with the availability of steel, after direct government orders are taken care of, in accordance with the degree of importance of the item of steel consumption involved.

There is, of course, a great deal of steel left while mills are taking care of government orders to the fullest extent possible. Such remaining steel falls into four classes: (1) Rejected ingots under government specifications; (2) crops required to be taken under government specifications; (3) Bessemer steel left after the relatively small proportion is furnished that is acceptable under government orders, and after the requirements of the tin plate trade are met; (4) steel at mills whose finishing capacity is limited, in the forms in which the government can use steel. Thus, as to the last item, there are mills equipped to roll little but merchant bars, the government requirements in that line being very much less than in plates, for example. There has been talk of attempting to divert ingots or billets from such mills to mills equipped with excess rolling capacity in government forms, but the proposition faces great difficulties.

As to the applicability of bessemer steel uses for which open-hearth has in recent years been given preference, the whims of consumers long recognized by steel makers are being given no attention. Of particular interest is the "sanitary" can, the can which does without solder by employing a tight seam. Since the development of the sanitary can and until quite recently open-hearth steel was regarded as absolutely essential, but practically all sanitary cans are now made of bessemer steel. The tin plate maker has to give the black plate special treatment in annealing. This involves an extra expense but it can readily be done.

### Production

Production of pig iron and steel has been steadily increasing, although rather slowly. Blast furnace capacity is estimated conservatively at 43,000,000 tons a year, taking the actual production in 1916 plus a safe allowance for new furnaces completed. Steel ingot capacity is 47,000,000 tons at a conservative estimate. Thus far in May pig iron production has been at 90 per cent of capacity at least, but ingot production has hardly been at as much as 90 per cent of capacity. Whatever might be the experience in normal times, it is quite improbable that 100 per cent operation of the blast furnaces would permit 100 per cent operation of the steel capacity, because there is not sufficient scrap.

## Chemical Market

Coal Tar Products: The demand for crudes has not undergone a great deal of change during the interval and continues quiet, with prices easier. The intermediates however are in better demand and prices for the most part are unchanged, with a tendency upward rather than otherwise.

*Benzol:* Large surplus offerings continue to back up on the market. Consumers are not buying heavily and prices registered further declines.

*Phenol:* Offers are more liberal, but the demand is light and prices are easier.

*Toluol:* Producers of the dye intermediates are receiving more liberal releases from the government, but other producers of intermediates are not receiving any. There continues to be small outside offerings at high prices.

*Naphthalene:* Quiet continues to prevail in this situation. Offers are more liberal, with the demand only routine.

*Benzoate of Soda:* There appears to be larger quantities of this material on the market than heretofore and prices are easing off as a result.

*Dimethylaniline:* Only a few producers are offering and prices are holding firm, with an active demand.

*Diethylaniline:* The production is confined to a few quarters and is not heavy; prices are inclined higher.

*Paranitraniline:* Only a few producers are offering; prices are higher, with an active demand.

*Aniline Oil:* Inquiries are numerous with prices unchanged.

*Beta Naphthol:* The technical grade is quite active, but the sublimed is quiet, with prices unchanged.

*Alpha Naphthylamine:* More of this material has been moving of late than formerly. Prices are practically unchanged, but the spot supply is lower.

*Metatolumylenediamine:* Recent releases of toluol have assisted toward increasing the production; the demand is active but not heavy.

*Para Amido Phenol:* Competing factors keep prices low and the production ample.

*Phthalic Anhydride:* This item is also lower in price due to the competition prevailing.

Heavy Chemicals: Business in products under this classification has been comparatively slow and unimportant during the past two weeks and the tendency in values has been to lower levels. Trading has mostly been in small lots and consumers apparently will not cover far forward needs at present trading levels. In a few of the products there have been pronounced flurries, due in some instances to speculation and in other directions to sudden demands from consuming trades.

*Caustic Soda:* A marked decline has occurred in this product since our last report and there has been very little important buying for the account of consumers. Prices have dropped from the level of 5c. store New York down to 4.35, at which offers are noted at the moment of writing. Philadelphia has sold material as low as 4.25. For forward positions producers have also come down in their views and there are now offers noted for contracts over the balance of the year at 4.75 works after the price of 5c. works prevailed for a long time. For 1919 business 3¼c. works basis 60% is quoted but no business is noted.

*Soda Ash:* This market has also been subject to a sharp decline in values, and at the moment of writing bags are available from New York store at 2.15—the lowest price that has prevailed for a lengthy period. Barrels are held at 2.60 to 2.70 and are somewhat firmer than bags, although there is no special movement noted.

*Acetic Acid:* This market has been one of the features of the situation the past two weeks. The 28% material has sold as high as 16c. barrels inclusive and the 56% material has sold at the unusually high price of 27¾c. barrels extra. This is probably the highest price on record. The principal accomplishment in the product at the moment is the locating of the supplies. Once stocks are located it is merely a matter of a few moments before the product is sold.

*Sulphuric Acid:* The market has been easier of late and sixty-six degree brimstone acid has been available as low as $33.00 per ton in sellers tanks works. The producers generally ask $35.00 sellers tanks works for the ordinary run of business. Very few offers of sixty degree material are noted, for as a rule the buyer prefers sixty-six degree material when same is available at a favorable figure. Ninety-seven per cent plus acid has on the other hand been very scarce and offers have been few and far between.

*Oleum:* The situation has improved the past few days and offers have been somewhat restricted. However it is still possible to do $65 drums extra but returnable for ordinary business. For tanks cars possibly $60.00 is workable. Some business in 60% oleum has been done at $225.00 per ton but the production has now been sold for the entire year and no further offers are noted.

*Yellow Prussiate of Soda:* The consuming demand has been so urgent that prices have been forced up to 50c., although transactions were noted at 37c. only a week or so ago. The production is confined to a few firms and is apparently not sufficiently large to take care of the consuming demand.

*Yellow Prussiate of Potash:* In common with most potash products the product is easier and there were offers during the past few days at $1.15 without attracting buyers. This is for American material. Japanese material is generally available at a somewhat lower figure.

*Cyanide of Soda:* The ordinary seller asks 40c. and upward but from second hands it is possible to do 38c. and on large business even this figure is shaded.

*Copper Sulphate:* Producers are not inclined to meet second-hand prices, but there is no denying the fact that these quotations are rather well establishing the market. Standard brands are available as low as 8¾c., although makers are quoting 9c. and even 9¼c.

*Bichromate of Soda:* The market has been such that it has been impossible to fathom it. Business has passed from 21c. up to 25c., and at the moment of writing 23½c. and 24c. is quoted. A few casks offered here and there are 23½c. and then a car is picked up at 24c. No one seems to understand just what is going on and who is doing it, but the product is subject to more fluctuation than any other chemical in this classification.

## General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, MAY 8, 1918

| | | | | |
|---|---|---|---|---|
| Acetic anhydride | lb. | 1.50 | — | 1.60 |
| Acetone, drums | lb. | Nominal | | |
| Acid, acetic, 28 per cent | lb. | Nominal | | |
| Acetic, 56 per cent | lb. | Nominal | | |
| Acetic, glacial, 99½ per cent., carboys | lb. | Nominal | | |
| Boric, crystals | lb. | .13¾ | — | .14½ |
| Citric, crystals | lb. | .87 | — | .88 |
| Hydrochloric, C. P | lb. | Nominal | | |
| Hydrochloric, 20 deg | lb. | .02¼ | — | .02¾ |
| Hydrochloric, conc., 22 deg | lb. | .02½ | — | .03 |
| Hydrofluoric, 30 per cent., in barrels | lb. | .06 | — | .06½ |
| Lactic, 44 per cent | lb. | .15½ | — | .16 |
| Lactic, 22 per cent | lb. | .06 | — | .06½ |
| Molybdic, 85 per cent | lb. | 3.85 | — | .... |
| Nitric, 36 deg | lb. | .08¼ | — | .08¾ |
| Nitric, 42 deg | lb. | .09 | — | .10 |
| Oxalic, crystals | lb. | .43 | — | .45 |
| Phosphoric, 47-50 per cent. paste | lb. | .08 | — | .10 |
| Phosphoric, ref. 50 per cent | lb. | .26 | — | .... |
| Picric | lb. | Nominal | | |
| Pyrogallic, resublimed | lb. | 3.10 | — | 3.15 |
| Sulphuric, 60 deg | ton | 25.00 | — | 27.50 |
| Sulphuric, 66 deg | ton | 35.00 | — | 40.00 |
| Sulphuric, oleum (Fuming), tank cars | ton | 60.00 | — | 75.00 |
| Tannic, U. S. P., bulk | lb. | 1.30 | — | 1.35 |
| Tartaric, crystals | lb. | .75 | — | .78 |
| Tungstic, per lb. of W | lb. | 1.70 | — | 1.75 |
| Alcohol, sugar cane, 188 proof | gal. | 4.93 | — | 4.95 |
| Alcohol, wood, 95 per cent | gal. | .90½ | — | .91 |
| Alcohol, denatured, 180 proof | gal. | .68 | — | .69 |
| Alum, ammonia lump | lb. | .04 | — | .04¼ |
| Alum, chrome ammonium | lb. | .18 | — | .19 |
| Alum, chrome potassium | lb. | .20 | — | .21 |
| Alum, chrome sodium | lb. | .12½ | — | .13 |
| Alum, potash lump | lb. | .08½ | — | .09 |
| Aluminium sulphate, technical | lb. | .02½ | — | .03 |
| Aluminium sulphate, iron free | lb. | .03¼ | — | .03½ |
| Ammonia aqua, 26 deg. carboys | lb. | .26 | — | .27 |
| Ammonia, anhydrous | lb. | Nominal | | |
| Ammonium carbonate | lb. | Nominal | | |
| Ammonium nitrate | lb. | (Fixed price) | | .15 |
| Ammonium, sulphate domestic | lb. | .07¾ | — | .08 |
| Amyl acetate | gal. | 5.00 | — | 5.25 |
| Arsenic, white | lb. | .17 | — | .18 |
| Arsenic, red | lb. | .65 | — | .70 |
| Barium carbonate, 99 per cent | ton | 80.00 | — | 90.00 |
| Barium carbonate, 97-98 per cent | ton | 65.00 | — | 67.00 |
| Barium chloride | ton | 65.00 | — | 85.00 |
| Barium sulphate (Blanc Fixe, Dry) | lb. | .02¼ | — | .02½ |
| Barium nitrate | lb. | .09½ | — | .10 |
| Barium peroxide, basis 70 per cent | lb. | .30 | — | .32 |
| Bleaching powder, 35 per cent. chlorine | lb. | .01½ | — | .02½ |
| Borax, crystals, sacks | lb. | .07¾ | — | .08½ |
| Brimstone, crude | ton | Nominal | | |
| Bromine, technical | lb. | .75 | — | .... |
| Calcium, acetate, crude | lb. | Nominal | | |
| Calcium, carbide | lb. | .13½ | — | .14 |
| Calcium chloride, 70-75 per cent., fused, lump | ton | 27.50 | — | 30.00 |
| Calcium peroxide | lb. | 1.60 | — | 1.70 |
| Calcium phosphate | lb. | .34 | — | .35 |
| Calcium sulphate 98-99 per cent | lb. | .09 | — | .09½ |
| Carbon bisulphide | lb. | .08½ | — | .10 |
| Carbon tetrachloride, drums | lb. | .15½ | — | .16 |
| Carbonyl chloride (phosgene) | lb. | 1.10 | — | 1.50 |
| Caustic potash, 88-92 per cent | lb. | .83½ | — | .84 |
| Caustic soda, 76 per cent | lb | .04½ | — | .04¾ |
| Chlorine, liquid | lb. | .15 | — | .18 |
| Cobalt oxide | lb. | 1.60 | — | 1.65 |
| Copperas | lb. | .01¼ | — | .01½ |
| Copper carbonate | lb. | .30 | — | .40 |
| Copper cyanide | lb. | .75 | — | .78 |
| Copper sulphate, 99 per cent., large crystals | lb. | .08½ | — | .09¼ |
| Cream of tartar, crystals | lb. | .80 | — | .82 |
| Epsom salt, bags, U.S.P | lb. | .03¼ | — | .03½ |
| Formaldehyde, 40 per cent | lb. | .18½ | — | .19 |
| Glauber's salt 100 | lb. | 1.50 | — | 2.00 |
| Glycerine, bulk, C. P | lb. | .63 | — | .64 |
| Iodine, resublimed | lb. | 4.25 | — | 4.30 |
| Iron oxide | lb. | .13 | — | .15 |
| Lead, acetate, white crystals | lb. | .17 | — | .18 |
| Lead, arsenate (Paste) | lb. | .15 | — | .18 |
| Lead nitrate | lb. | .15 | — | .16 |
| Litharge, American | lb. | .09½ | — | .11½ |
| Lithium carbonate | lb. | 1.50 | — | 2.00 |
| Manganese dioxide, U. S. P | lb. | .70 | — | .75 |
| Magnesium carbonate, technical | lb. | .10½ | — | .11 |
| Nickel salt, single | lb. | .14 | — | .15 |
| Nickel salt, double | lb. | .12 | — | .14 |
| Phosgene, see Carbonyl chloride | | | | |
| Phosphorus, red | lb. | 1.30 | — | 1.50 |
| Phosphorus, yellow | lb. | 1.50 | — | 1.60 |
| Potassium bichromate | lb. | .44 | — | .46 |
| Potassium bromide granular | lb. | 1.35 | — | 1.50 |
| Potassium carbonate calcined, 85-90 per cent | lb. | .40 | — | .50 |
| Potassium chlorate, crystals | lb. | .38 | — | .40 |
| Potassium cyanide, 98-99 per cent | lb. | Nominal | | |
| Potassium iodide | lb. | 3.75 | — | 3.80 |
| Potassium muriate 80-85 p. c. basis of 80 p. c | ton | 325.00 | — | 350.00 |
| Potassium nitrate | lb. | .27 | — | .31 |
| Potassium permanganate (U. S. P.) | lb. | 3.65 | — | 3.75 |
| Potassium prussiate, red | lb. | 2.80 | — | 2.90 |
| Potassium prussiate, yellow | lb. | 1.15 | — | 1.20 |
| Potassium sulphate, 90-95 p. c. basis 90 p. c | ton | Nominal | | |
| Rochelle salts | lb. | .43 | — | .44 |
| Salammoniac, gray gran | lb. | .18 | — | .19 |
| Salammoniac, white gran | lb. | .15¾ | — | .16 |
| Sal soda 100 | lb. | 1.35 | — | 1.40 |
| Salt cake | ton | 22.50 | — | 25.00 |
| Silver cyanide, based on market price of silver | oz. | .... | — | .... |
| Silver nitrate | oz. | .61½ | — | .62 |
| Soda ash, 58 per cent., light, flat (bags) 100 | lb. | 2.20 | — | 2.30 |

| | | | | |
|---|---|---|---|---|
| Soda ash, 58 per cent., dense, flat | 100 lb. | 3.65 | — | .... |
| Sodium acetate | lb. | .23 | — | .24 |
| Sodium bicarbonate, domestic | lb. | .02¼ | — | .03 |
| Sodium bicarbonate, English | lb. | .... | — | .... |
| Sodium bichromate | lb. | .24 | — | .25 |
| Sodium bisulphite, powd | lb. | .05½ | — | .06 |
| Sodium chlorate | lb. | .24 | — | .25 |
| Sodium cyanide | lb. | .38 | — | .40 |
| Sodium fluoride, commercial | lb. | .18 | — | .19 |
| Sodium hyposulphite | lb. | .02½ | — | .02¾ |
| Sodium molybdate, per lb. of Mo | lb. | 2.50 | — | .... |
| Sodium nitrate, 95 per cent | 100 lb. | Nominal | | |
| Sodium nitrite | lb. | .29 | — | .32 |
| Sodium peroxide | lb. | .48 | — | .50 |
| Sodium phosphate | lb. | .04 | — | .05 |
| Sodium prussiate, yellow | lb. | .50 | — | .52 |
| Sodium silicate, liquid (60 deg.) | lb. | Nominal | | |
| Sodium sulphide, 30 per cent., crystals | lb. | .02½ | — | .03 |
| Sodium sulphide, 60 per cent., fused | lb. | .06 | — | .... |
| Sodium sulphite | lb. | Nominal | | |
| Strontium nitrate | lb. | .25 | — | .35 |
| Sulphur chloride, drums | lb. | .06 | — | .06½ |
| Sulphur dioxide, liquid, in cylinders | lb. | .15 | — | .40 |
| Sulphur, flowers, sublimed | 100 lb. | 4.05 | — | 4.60 |
| Sulphur, roll | 100 lb. | 3.70 | — | 3.85 |
| Sulphur, crude | ton | Nominal | | |
| Tin bichloride, 50 deg. | lb. | .23½ | — | .24½ |
| Tin oxide | lb. | .78 | — | .80 |
| Zinc carbonate | lb. | .25 | — | .30 |
| Zinc chloride | lb. | .12½ | — | .13 |
| Zinc cyanide | lb. | Nominal | | |
| Zinc dust, 350 mesh | lb. | .14 | — | .16 |
| Zinc oxide, American process XX | lb. | .12½ | — | .14 |
| Zinc sulphate | lb. | .05 | — | .06 |

## Coal Tar Products (Crude)

| | | | | |
|---|---|---|---|---|
| Benzol, pure, water white | gal. | .27 | — | .30 |
| Benzol, 90 per cent | gal. | .... | — | .... |
| Toluol, pure, water white | gal. | 1.75 | — | 5.50 |
| Xylol, pure, water white | gal. | .35 | — | .50 |
| Solvent naphtha, water white | gal. | .17 | — | .22 |
| Solvent naphtha, crude, heavy | gal. | .13 | — | .16 |
| Creosote oil, 25 per cent | gal. | .33 | — | .35 |
| Dip oil, 20 per cent | gal. | .29 | — | .30 |
| Pitch, various grades | ton | 8.00 | — | 20.00 |
| Carbolic acid, crude, 95-97 per cent | lb. | 1.05 | — | 1.10 |
| Carbolic acid, crude, 50 per cent | lb. | .60 | — | .65 |
| Carbolic acid, crude, 25 per cent | lb. | .35 | — | .38 |
| Cresol, U. S. P. | lb. | .18 | — | .20 |

## Intermediates, Etc.

| | | | | |
|---|---|---|---|---|
| Alpha naphthol, crude | lb. | 1.00 | — | 1.25 |
| Alpha naphthol, distilled | lb. | 1.60 | — | 2.00 |
| Alpha naphthylamine | lb. | .60 | — | .61 |
| Aniline oil, drums extra | lb. | .25½ | — | .27 |
| Aniline salts | lb. | .33 | — | .34 |
| Anthracene, 80 per cent | lb. | .50 | — | .65 |
| Benzaldehyde (f.f.c.) | lb. | 5.50 | — | 6.00 |
| Benzidine, base | lb. | 1.75 | — | 1.85 |
| Benzidine, sulphate | lb. | 1.40 | — | 1.50 |
| Benzoic acid U. S. P. | lb. | 4.00 | — | 4.10 |
| Benzoate of Soda, U. S. P. | lb. | 3.75 | — | 3.90 |
| Benzyl chloride | lb. | 2.25 | — | 2.75 |
| Beta naphthol benzoate | lb. | 10.00 | — | 12.00 |
| Beta naphthol, sublimed | lb. | .85 | — | .90 |
| Beta naphthylamine, sublimed | lb. | 2.65 | — | .... |
| Dichlor benzol | lb. | .12 | — | .18 |
| Diethylaniline | lb. | 4.50 | — | 5.00 |
| Dinitro benzol | lb. | .35 | — | .40 |
| Dinitrochlorbenzol | lb. | .40 | — | .42 |
| Dinitronaphthaline | lb. | .55 | — | .60 |
| Dinitrotoluol | lb. | .55 | — | .60 |
| Dinitrophenol | lb. | .46 | — | .50 |
| Dimethylaniline | lb. | .65 | — | .70 |
| Diphenylamine | lb. | 1.00 | — | 1.10 |
| H-acid | lb. | 2.25 | — | 2.50 |
| Metaphenylenediamine | lb. | 2.00 | — | 2.25 |
| Monochlorbenzol | lb. | .17 | — | .19 |
| Naphthalene, flake | lb. | .10 | — | .10½ |
| Naphthalene, balls | lb. | .12 | — | .13 |
| Naphthionic acid, crude | lb. | 1.20 | — | 1.30 |
| Naphthylamin-di-sulphonic acid | lb. | 1.00 | — | 1.10 |
| Nitro naphthaline | lb. | .45 | — | .50 |
| Nitro toluol | lb. | .50 | — | .55 |
| Ortho-amidophenol | lb. | .... | — | .... |
| Ortho-dichlor-benzol | lb. | .15 | — | .18 |
| Ortho-toluidine | lb. | 1.00 | — | 1.25 |
| Ortho-nitro-toluol | lb. | .75 | — | 1.00 |
| Para-amidophenol, base | lb. | 3.50 | — | 3.75 |
| Para-amido-phenol, H. Ch | lb. | 4.00 | — | 5.00 |
| Para-dichlor-benzol | lb. | .12 | — | .15 |
| Paranitraniline | lb. | 1.28 | — | 1.30 |
| Para-nitro-toluol | lb. | 1.50 | — | 1.60 |
| Paraphenylenediamine (base) | lb. | 3.00 | — | 3.25 |
| Para toluidine | lb. | 2.25 | — | 2.50 |
| Phthalic acid anhydride | lb. | 3.50 | — | 4.00 |
| Phenol, U. S. P. | lb. | .50 | — | .52 |
| Resorcin, technical | lb. | 5.75 | — | 6.00 |
| Resorcin, pure | lb. | 8.50 | — | 9.00 |
| Salicylic acid | lb. | .95 | — | 1.00 |
| Salol | lb. | 1.90 | — | 2.00 |
| Sulphanilic acid, crude | lb. | .32 | — | .35 |
| Tolidin | lb. | 2.50 | — | .... |
| Toluidine-mixture | lb. | .75 | — | .85 |

## Petroleum Oils

Crude (at the Wells)

| | | | | |
|---|---|---|---|---|
| Pennsylvania | bbl. | 4.00 | — | .... |
| Corning, Ohio | bbl. | 2.85 | — | .... |
| Somerset, Ky | bbl. | 2.60 | — | .... |
| Wooster, Ohio | bbl. | 2.58 | — | .... |
| Indiana | bbl. | 2.18 | — | .... |
| Illinois | bbl. | 2.32 | — | .... |
| Oklahoma and Kansas | bbl. | 2.25 | — | .... |
| Caddo, La., light | bbl. | 2.25 | — | .... |
| Corsicana, Tex., light | bbl. | 2.35 | — | .... |
| California | bbl. | .98 | — | 1.32 |
| Gulf Coast | bbl. | 1.35 | — | .... |

Fuel Oil

| | | | | |
|---|---|---|---|---|
| New York | gal. | .11 | — | .... |
| Pittsburgh | gal. | .07½ | — | .10 |
| Oklahoma-Kans | bbl. | 1.05 | — | 2.75 |
| Texas | bbl. | 1.50 | — | 1.90 |
| Los Angeles | bbl. | 1.52 | — | .... |
| San Francisco | bbl. | 1.45 | — | .... |

Gasoline (Wholesale)

| | | | | |
|---|---|---|---|---|
| New York | gal. | .24 | — | .... |
| Boston | gal. | .25 | — | .... |
| Pittsburgh | gal. | .28 | — | .... |
| Chicago | gal. | .22½ | — | .... |
| Oklahoma | gal. | .25 | — | .... |
| San Francisco | gal. | .20 | — | .... |

## Lubricants

| | | | | |
|---|---|---|---|---|
| Black, reduced, 29 gravity, 25-30 cold test | gal. | .21 | — | .22 |
| Cylinder, light | gal. | .36 | — | .38 |
| Cylinder, dark | gal. | .35 | — | .36 |
| Paraffine, high viscosity | gal. | .40 | — | .41 |
| Paraffine, .903 sp. gr | gal. | .36 | — | .38 |
| Paraffine, .885 sp. gr | gal. | .26 | — | .28 |

## Flotation Oils

(Prices at New York unless otherwise stated)

| | | | | |
|---|---|---|---|---|
| Pine oil, crude, f. o. b. Florida | gal. | .44 | — | .... |
| Pine oil, steam-distilled, sp. gr. 0.925-0.940 | gal. | .53 | — | .... |
| Pine oil, destructively distilled | gal. | .49 | — | .53 |
| Pine-tar oil, sp. gr., 1.025-1.035 | gal. | .35 | — | .... |
| Pine-tar oil, double refined, sp. gr. 0.965-0.990 | gal. | .40 | — | .... |
| Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f. o. b. works | gal. | .35 | — | .... |
| Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f. o. b. works | gal. | .35 | — | .... |
| Pine-tar oil, ref., thin, sp. gr. 1.060-1.080 | gal. | .30 | — | .... |
| Turpentine, crude, sp. gr. 0.980-1.000 | gal. | .40 | — | .... |
| Hardwood oil, f. o. b. Michigan, sp. gr. 0.960-0.990 | gal. | .19 | — | .... |
| Hardwood oil, f. o. b. Michigan, sp. gr. 1.06-1.08 | gal. | .19 | — | .... |
| Wood creosote, ref. f. o. b. Florida | gal. | .31 | — | .... |

## Vegetable and Other Oils

| | | | | |
|---|---|---|---|---|
| China wood oil | lb. | .26 | — | .27 |
| Cottonseed oil, crude | lb. | .17½ | — | .18 |
| Linseed oil, raw, cars | gal. | 1.57 | — | 1.59 |
| Peanut oil, crude | gal. | 1.37 | — | .... |
| Rosin oil, first run | gal. | .41 | — | .... |
| Rosin oil, fourth run | gal. | .58 | — | .... |
| Soya bean oil, Manchuria | lb. | .19½ | — | .19¾ |
| Turpentine, spirits | gal. | .44 | — | .44½ |

## Miscellaneous Materials

| | | | | |
|---|---|---|---|---|
| Barytes, floated, white, foreign | ton | Nominal | | |
| Barytes, floated, white, domestic | ton | 32.00 | — | 36.00 |
| Beeswax, white, pure | lb. | .60 | — | .62 |
| Casein | lb. | .14½ | — | .18 |
| Chalk, light, precipitated, English | lb. | Nominal | | |
| China clay, imported, lump | ton | 17.50 | — | 36.00 |
| China clay, domestic, lump | ton | 12.50 | — | 20.00 |
| Feldspar | ton | 8.00 | — | 12.00 |
| Fluorspar, gravel, f. o. b. mines | ton | 33.00 | — | 35.00 |
| Fuller's earth, powdered | 100 lb. | 1.00 | — | 1.50 |
| Graphite, flake | lb. | .15 | — | .18 |
| Ozokerite, crude, brown | lb. | Nominal | | |
| Ozokerite, American, refined, white | lb. | Nominal | | |
| Red lead, dry, carloads | lb. | .10 | — | .11½ |
| Rosin, 280 lb. | bbl. | 6.15 | — | .... |
| Soapstone | ton | 10.00 | — | 12.50 |
| Talc, American, white | ton | 15.00 | — | 22.00 |
| White lead, dry | lb. | .09 | — | .10 |

## Refractories, Etc.

(F. O. B. Works)

| | | | | |
|---|---|---|---|---|
| Chrome brick | net ton | Nominal | | |
| Chrome cement, Grecian | net ton | Nominal | | |
| Clay brick, 1st quality fireclay | per 1000 | 50.00 | — | 55.00 |
| Clay brick, second quality | per 1000 | 35.00 | — | 40.00 |
| Magnesite, raw | ton | 30.00 | — | 35.00 |
| Magnesite, calcined | ton | 32.00 | — | 35.00 |
| Magnesite, Grecian, dead burned | net ton | 70.00 | — | 75.00 |
| Magnesia brick, Grecian, 9x4½x2½ | net ton | 130.00 | — | 135.00 |
| Silica brick | per 1000 | 50.00 | — | 60.00 |

## Ferroalloys

| | | | | |
|---|---|---|---|---|
| Ferrocarbontitanium, 15-18 per cent., carloads, f. o. b. Niagara Falls, N. Y. | ton | 200.00 | — | .... |
| Ferrocerium | lb. | 20.00 | — | .... |
| Ferrochromium, per lb. of Cr | lb. | .50 | — | .... |
| Ferromanganese, domestic, 70 per cent. basis | ton | 250.00 | — | .... |
| Ferromanganese, English | ton | 325.00 | — | .... |
| Ferromolybdenum, per lb. of Mo | lb. | 5.00 | — | .... |
| Ferrosilicon, 75 per cent., f. o. b., N. Y. | ton | .... | — | .... |
| Ferrosilicon, 50 per cent., carloads, del., Pittsburgh | ton | 180.00 | — | 190.00 |
| Ferrosilicon, 50 per cent., contract | ton | 100.00 | — | 175.00 |
| Ferrotungsten, 75-85 per cent., f. o. b., Pittsburgh | lb. | 2.35 | — | 2.40 |
| Ferrouranium, f. o. b. works, per lb. of U | lb. | 7.00 | — | 7.50 |
| Ferrovanadium, f. o. b. works | lb. | 4.00 | — | 5.00 |

## Ores and Semi-finished Products

| | | | | |
|---|---|---|---|---|
| Antimony ore, per unit | ton | 1.60 | — | 1.75 |
| Chrome ore, 45 per cent. minimum, f.o.b. Cal., per unit | ton | 1.40 | — | 1.60 |
| Chrome ore, 43 per cent. and over, New York, per unit | ton | 1.50 | — | .... |
| Manganese ore, 48 per cent. and over, per unit | ton | 1.20 | — | .... |
| Manganese ore, chemical | ton | 80.00 | — | 100.00 |
| Molybdenite, per lb. of $MoS_2$ | lb. | 1.80 | — | .... |
| Tungsten, Scheelite, per unit of $WO_3$ | ton | 24.50 | — | .... |
| Tungsten, Wolframite, per unit of $WO_3$ | ton | 24.00 | — | .... |
| Uranium oxide, 96% | lb. | 3.25 | — | 3.60 |
| Vanadium pentoxide, 99% | lb. | 10.50 | — | .... |
| Pyrites, foreign | unit | .17 | — | .17½ |
| Pyrites' domestic | unit | .28 | — | .30 |

# INDUSTRIAL

*Financial, Construction and Manufacturers' News*

## New Companies

The ALLEN MANUFACTURING COMPANY, Quakerown, N. J. Capital, $10,000. To engage in the manufacture of chemicals and allied products. Incorporators: Harry W. Haver, Walter A. Allen, Harry M. Oakes and George E. Rose, Quakertown.

The AMERICAN INGRAFT COMPANY, INC., New York. Capital, $25,000. To manufacture chemicals, etc. Morris Yedlin, Brooklyn, is the principal incorporator.

The BROWN CHEMICAL COMPANY, Maplewood, N. J. Capital, $500,000. To manufacture chemicals and allied specialties. Incorporators: Oscar G. Brown, F. M. Brown, Maplewood, and Arthur C. Hamilton, West Orange.

The CAPSTAN GLASS COMPANY, Philadelphia, Pa. Capital, $300,000. To engage in the manufacture of glass and glassware. Incorporators: H. A. Stein, Sharon Hill, Pa.; J. V. Pimm and S. C. Seymour, Camden, N. J.

The CHRISMAN PARAFFINE PAINT WORKS, INC., Eldrad, Pa. Capital, $20,000. To manufacture paints, varnishes, &c. Incorporators: Benjamin G. McFall, Bruce H. Clark and Frank F. Mack, Eldrad, Pa.

KELLY BROTHERS MANUFACTURING COMPANY, Belington, W. Va. Capital, $50,000. To operate a local foundry. Incorporators: J. F., M. J. and J. P. Kelly, Elkins; J. A. and H. V. Viquesney, Belington.

The KNICKERBOCKER DYESTUFF COMPAY, New York. Capital, $10,000. To engage in the manufacture of dyestuffs, etc. Incorporators: M. Mackenzie, A. H. Gleason and J. J. Hayden, 258 Broadway.

The MANCHESTER SUGAR COMPANY, Boston, Mass. Capital, $50,000. To manufacture sugar. Incorporators: Benjamin P. Levy, N. Harrison and I. Gordon, Boston.

The MAUMEE IRON & STEEL COMPANY, Toledo, O. Capital, $50,000. To engage in the manufacture of iron and steel products. George W. Ritter is the principal incorporator.

The METRO COLOR & CHEMICAL WORKS, Brooklyn, N. Y. Capital, $75,000. To operate a plant for the manufacture of chemicals, dyestuffs, etc. Incorporators: A. Petersen, M. Goldhammer and R. Jensen, 760 St. Ann's Avenue.

The MIDDLESEX RENDERING COMPANY, Middletown, Conn. Capital, $25,000. To operate a local rendering plant. Incorporators: Berkley C. Stone, Frank H. Frissell and Dennis J. O'Brien, Middletown.

The NEW ERA ORE REDUCTION COMPANY, Philadelphia, Pa. Capital, $2,500,000. To engage in the development of mining properties and the reduction of ore. Incorporators: Wray C. Arnold, Harold C. Lansinger and M. Elliott, Philadelphia.

The O'BRIEN SYNTHETIC DYE COMPANY, South Bend, Ind. Capital, $50,000. To manufacture chemicals, dyestuffs, etc. Incorporators: Jerome J. Crowley, George L. O'Brien, Will G. Crabill, S. J. Crumpacker and Ray Heylman, South Bend.

The POUGHKEEPSIE PAINT COMPANY, Poughkeepsie, N. Y. Capital, $10,000. To manufacture paints, varnishes, etc. Incorporators: H. Lloyd, Jr., C. and H. Sague, Poughkeepsie.

The PROSPECT PAINT COMPANY, Bronx, N. Y. Nominal capital, $5,000. To operate a plant for the production of paints. Incorporators: F. Elsen, S. Roth and S. Hauptman, 1066 Prospect Avenue.

The PYODINE CHEMICAL COMPANY, Los Angeles, Cal. Capital, $25,000. To engage in the manufacture of chemicals, etc. Incorporators: Dr. David Osterhold, E. Osterhold and Fred B. Osterhold, 1141 North Coronado Street.

The PYROPHORIC METALS COMPANY, Newark, N. J. Capital, $100,000. To deal in metals and alloys. Incorporators: George W. Cunningham, Paterson; William Rea, Bloomfield, and William Bonnman, Passaic, N. J.

The SEMINOLE PHOSPHATE MINING COMPANY, Croom, Fla. Capital, $60,000. To mine for phosphate. Incorporators: W. F. Walker, E. N. Morrow, Croom, and A. P. Petway, Eastman, Ga.

The VELORA COMPANY, New York. Capital, $250,000. To engage in the manufacture of chemicals, etc. Incorporators: E. S. M. Selig, A. B. Crawford and F. Aranow, 27 Cedar Street.

S. WALTER, INC., Philadelphia, Pa. Capital, $75,000. To engage in the manufacture of paper and paper products. Harry Lefkowith is the principal incorporator.

The WATERVILLE FOUNDRY & MANUFACTURING COMPANY, Waterville, N. Y. Capital, $25,000. To operate a foundry for the manufacture of castings and machinery. Incorporators: William G. McLean, Charles W. McLean, Waterville, and George I. Hovey, Deansboro.

The WEST VIRGINIA LEAD & ZINC COMPANY, Parkersburg, W. Va. Capital, $300,000. To engage in the development of lead and zinc properties in the Miami district, Okla. Incorporators: Charles Heinselman, A. D. Sees, A. A. Haught and H. B. Reid.

The WILMINGTON PAINT & GLASS COMPANY, Wilmington, Del. Capital, $50,000. To operate a plant for the manufacture of paints, glass, etc. Incorporators: Harry B. Patten, William F. Johnson and John L. Byrne, Wilmington.

## Constructions and Operation

### Connecticut

HARTFORD.—U. S. Ordnance Corps, Washington, D. C., will build a plant here and install machinery for producing toluol from gas. Hartford City Gas Co., 565 Main St., will produce about 50,000 gal.

NEW BRITAIN.—The New Britain Machine Co., Chestnut St., has purchased a site of land on South St. on which they plan to construct a 100 x 310 ft. factory to cost approximately $125,000.

### Georgia

MACON.—The Macon Gas Co. will build a $40,000 addition to its plant, increasing the monthly capacity to 36,000,000 cu. ft. gas for lighting and heating.

### Illinois

CHICAGO.—Bauer & Black, 25th St. and Dearborn Ave., manufacturer of druggist specialties, will build a 7-story, 75 x 108 reinforced concrete addition to factory. Hobart & Roche, 1401 Monroe Bldg., architects.

CHICAGO.—Harrington & King Co., 614 North Union Ave., manufacturer of perforated sheet metal, will build a 1-story, 126 x 372 ft. mill construction factory at Campbell and Taylor Sts. George C. Nimmons & Co., 2005 Peoples Gas Building, engineer.

### Kentucky

NEW ALBANY—The United Chemical Co., 111 West Washington St., Chicago, Ill., has acquired a tract of land in New Albany comprising about 55 acres on which they plan to construct a large plant for the manufacture of chemicals.

### Maine

BIDDEFORD.—The Saco-Lowell Shops, Biddeford, has awarded the contract for the construction of a 1-story, 36 x 92 x 107 ft. brick and steel factory addition to the Flynt Building & Construction Co., 356 Main St., Palmer, Mass.

### Maryland

BALTIMORE.—The Bartlett Hayward Co., Scott and McHenry Sts., has awarded the contract for the construction of a 1-story, 90 x 252 ft. assembly shop, to Morrow Bros., Fidelity Bldg., Baltimore. Estimated cost, $55,000.

CUMBERLAND.—The Kelly-Springfield Tire Co., Cook St., Akron, Ohio, will build a new plant here to cost approximately $1,000,000.

### Massachusetts

HOLYOKE.—The Worthington Pump & Machinery Corporation, Deane Works, Appleton St., is planning to build a 150 x 200 ft. machine and erecting shop, and a 50 x 200 ft. foundry, brick and steel frame. Estimated cost, $225,000. Lyman R. Howes, c/o Deane Works, is engineer.

SOMERVILLE.—The Vacuum Co., 105 Mystic Ave., has awarded the contract for the construction of a 2-story, 60 x 198 ft. timber fumigating plant on concrete pile foundation, to Barney Ahlers Corporation, 110 West 40th St., New York City. Estimated cost, $15,000.

### Michigan

DETROIT.—The Packard Motor Car Co., East Grand Boulevard, will build an addition to its factory on Mt. Elliott Ave., to cost $15,000.

### Minnesota

MINNEAPOLIS.—Goldberg Bros., 922 Washington Ave., will build a 1-story, 13 x 40 x 80 ft., brick brass foundry by day labor. Estimated cost, $4,500.

### New Jersey

KEARNY—(Arlington P. O.)—Swift & Co., Union Stock Yards, Chicago, Ill., will build a 5 story, reinforceed concrete rendering plant on the Kearny Meadows to have a capacity of approximately 3,000,000 pounds of raw product. The company plans to complete the plant in three months and it will probably be the largest works of its kind in the east.

BLOOMFIELD.—The General Electric Co., Sprague Works, has awarded the contract for the construction of a 1-story, 100 x 160 ft., reinforced concrete, steel and brick factory, to Austin Co., 16112 Euclid Avenue, Cleveland, Ohio. Estimated cost, $35,000.

HASKELL—The E. I. duPont de Nemours Co., Wilmington, Del., is building a 1-story, 20 x 40 ft. addition to its plant here. James Lynah is superintendent.

NEWARK—The Butterworth Judson Corporation, Avenue R, manufacturer of chemicals, has had plans prepared for the construction of a 1 story, brick and steel absorption tower at its plant here. Estimated cost $30,000.

### New York

BROOKLYN—The Long Island Soap Co., Bridgewater St. and Meeker Ave., has awarded the contract for the construction of a 3 story, reinforced-concrete factory, to the Gabler Construction Co., 402 Hudson St., New York. Estimated cost, $38,000.

NEW YORK—The American Balso Corporation, manufacturer of chemicals, 30 East 42nd St., has awarded the contract for the construction of a 1 story, 138 x 185 ft., concrete, brick and steel factory to be built at the foot of 153rd St. and Harlem River, to C. G. Flygar, 405 Lexington Ave., New York. Estimated cost, $70,000.

NEW YORK—The Vulcan Proofing Co., 583 Dean St., Brooklyn, has awarded the contract for the construction of a 2 story 130 x 308 ft. concrete factory on 57th St., west of 1st Ave., to Turner Construction Co., 244 Madison Ave., New York. Estimated cost, $200,000.

TUCKAHOE——The Hodgeman Rubber Co. has awarded the contract for the construction of a 1 story 60 x 160 ft. concrete, brick and steel factory to cost $20,000 to Austin Co., 16112 Euclid Ave., Cleveland, Ohio.

WATERTOWN—Fire May 4, destroyed the sulphite mill at the plant of the International Paper Co. on Sewells Island with a loss of approximately $100,000. The company plans to rebuild same.

### North Dakota

GRAND FORKS—The University of North Dakota has awarded the contract for the construction of a 3 story chemistry building to the Dakota Construction Co., 376 Plymouth Building, Minneapolis, Minn. Estimated cost, $62,483.

### Ohio

AKRON.—The Goodyear Tire & Rubber Co., East Market St., has awarded the contract for the construction of a 3 story,

170 x 400 ft., steel, brick and concrete balloon factory, to the Hunkin-Conkey Construction Co., 321 Cuyahoga Building, Cleveland. Estimated cost, $450,000.

AKRON—The Phoenix Rubber Co., Wrigley Ave., has awarded the contract for the construction of a 1 story, 50 x 100 ft., and a 1 story, 30 x 30 ft., brick and steel frame factory, to Clemmer & Johnson Co., High and Church Sts., Akron, to cost, $8000.

CINCINNATI—The Cincinnati Ball Crank Co., plans to build a brick machine shop as an addition to its factory at 3167 Densey Ave., Oakley. Estimated cost, $35,-000.

CINCINNATI—The contract has been awarded to the Fisher-DeVore Electric Co. for the construction of a 6 story, reinforced concrete plant for the Luilaw-Dunn-Gordon Co., machine tool manufacturers. Estimated cost $90,000.

CINCINNATI—The Peerless Foundry Co., 11th and High Sts., Hamilton, will build a 120 x 200 ft. grey iron foundry, fireproof construction.

CINCINNATI—The United States Electric Tool Co. plans to build a 2 story, brick manufacturing building at 2488 West 6th St. Estimated cost, $15,000.

CLEVELAND—The Aluminum Rolling Mills Co., Ivanhoe Rd., will build a 1 story 81 x 399 ft., concrete, brick, and steel aluminum rolling mill. Estimated cost, $100,000.

CLEVELAND—The Globe Machine & Stamping Co., 1250 West 76th St., has awarded the contract for the construction of a 4 story, 100 x 150 ft., steel and brick metal factory, to Craig Curtis Co., 1031 Guardian Bldg., Cleveland. Estimated cost $125,000.

CLEVELAND—The Hoffman Bronze Co. Addison Rd., has awarded the contract for the construction of a 1 story, 50 x 101 ft., brick bronze foundry, to A. H. Howard, 1528 Larchmont Ave., Cleveland. Estimated cost, $10,000.

CLEVELAND—The Masek Glue Co., 908 Denison Ave., has awarded the contract for the construction of a 1 story, 30 x 60 ft., brick and steel glue factory, also a 2 story, 20 x 88 ft., reinforced concrete, brick and steel reduction plant, to the Masters & Mullen Construction Co., Electric Building, Cleveland. Estimated cost, $40,000.

CLEVELAND — The Parrish-Bingham Co., 10600 Madison Ave., has awarded the contract for the construction of a 1 story, 120 x 144 ft. building for hardening and picking steel, to W. I. Thompson & Son Co. Estimated cost, $30,000.

CLEVELAND—The Standard Foundry and Manufacturing Co., 2717 East 75th St., has awarded the contract for the construction of a 1 story 35 x 100 ft., brick and steel factory, to D. Lindhorst Construction Co., 807 American Trust Building, Cleveland. Estimated cost $5,000.

DAYTON—The Machines Co., Essex Ave., will build a 3 story, 70 x 150 ft., reinforced concrete and brick factory for the manufacture of optical instruments. Estimated cost, $75,000.

DAYTON—The Ohmer Fare Register Co., Bolander Ave., has awarded the contract for the construction of a 1 story 90 x 300 ft., reinforced concrete, steel, and brick factory to cost $50,000, to Blanchard Contracting Co., 601 Reibold Building, Dayton.

### Pennsylvania

CHESTER—John A. Worrell, 905 West 8th St., will construct a 1 story brass foundry at 8th and Springwell Sts.

PHILADELPHIA—The American Manganese Bronze Co., Rhawn and Hegerman Sts., has had plans prepared for the construction of an addition to its foundry in Holmesburg.

PHILADELPHIA—The Fairmount Foundry Co., Mascher and Duncannon Sts., will construct a 1 story, 22 x 100 ft., addition to its foundry.

PHILADELPHIA—John T. Lewis & Sons Co., Lafayette Building, has awarded the contract for the construction of a 1 story, 108 x 180 ft., brick and steel building, at Aramingo and Huntingdon Aves., to the Turner Concrete Steel Co., 1713 Sansom St., Philadelphia. Estimated cost, $10,000.

PHILADELPHIA—Wm. Sellers & Co., 16th and Hamilton Sts., will build a 5 story, 25 x 50 ft., brick, concrete, and steel addition to its plant to be used as an injector shop, to cost $15,000.

PHILADELPHIA—C. F. Simmons Sons, Belgrade and Tioga Sts., has awarded the contract for the construction of a 1 story 35 x 100 ft., brick factory addition for the manufacture of fertilizers and oils, to Harry Gill, Jr., 2515 Germantown Ave. Estimated cost $7000.

PITTSBURGH—The E. R. Moore Co., Union Bank Building, has awarded the contract for the construction of a 1 story, 65 x 200 and 60 x 160 ft., reinforced concrete, brick and steel factory building, to Austin Co., 16112 Euclid Ave., Cleveland, Ohio. Estimated cost $45,000.

### Rhode Island

PAWTUCKET—The Narragansett Machine Co., Vale St., has awarded the contract for the construction of a 2 story 60 x 130 and 50 x 86 ft. reinforced concrete, brick and steel manufacturing building, to W. H. Hamlyn & Son., 35 Greenwich St., Providence. Estimated cost, $50,000.

### Tennessee

CHATTANOOGA—(Alton Park)—The F. J. Lewis Manufacturing Co., 2513 South Robey St., Chicago, Ill., manufacturer of roofing, etc., has purchased a site at Alton Park on which they plan to construct a branch factory.

### Virginia

PULASKI—The Pulaski Foundry & Manufacturing Co. plans to build an addition to its foundry here which will double the present capacity.

### Wisconsin

CUDAHY—The Great Lakes Rubber Co., Milwaukee, recently incorporated, plans to construct a factory here for the production of molded and mechanical rubber goods. First unit of plant will provide for 40,-000 sq. ft. space. Donald C. Barbee, 140 Reed St., Milwaukee, is interested.

MILWAUKEE—The Federal Malleable Co., 299-323 Sixty Fourth Ave., plans to build an addition to its foundry at West Allis.

WATERTOWN—The Monarch Tractor Co., Watertown, has awarded the contract for the construction of a 140 x 160 ft., brick and steel machine shop and assembly unit, to the Austin Co., 16112 Euclid Ave., Cleveland, Ohio.

## New Publications

**The Collapse of Short Thin Tubes, By Prof. A. P. Carman of the University of Illinois. Bulletin 99 of the Engineering Experiment Station, Urbana, Ill.**

**The Republic of Bolivia. Official Information and Statistics, Summarized by Señor Julio Zamora, Minister of Foreign Relations, Woolworth Bldg., New York.**

**Emergency Training in Shipbuilding. Description of Evening and Part-Time Classes for Shipyard Workers. Bulletin No. 3 of Federal Board for Vocational Education, Washington.**

**Mechanical and Technical Training for Conscripted Men. (Air Division U. S. Signal Corps), Bulletin No. 4, Federal Board for Vocational Education, Washington.**

**Mineral Industries of the United States. The following publications have been issued by the Smithsonian Institute, Washington. Bulletin 102, Parts 1, 2 and 3: Coal Products. By Chester G. Gilbert; Fertilizer. By Joseph E. Pogue; Sulphur. By Joseph E. Pogue.**

**New Bureau of Mines Publications: The Mining Industry in Alaska. By S. S. Smith. Bulletin 153.**

**New Bureau of Standards Publications: Combined Table of Sizes in the Principal Wire Gages. Circular 67. Gas Interferometer Calibration. By J. D. Edwards. Scientific Paper No. 316; Latent Heat of Vaporization of Ammonia. By Nathan S. Osborne and M. S. Van Dusen. Scientific Paper No. 315; Latent Heat of Pressure Variation of Liquid Ammonia. By Nathan S. Osborne and M. S. Van Dusen. Scientific Paper No. 314; Specific Heat of Liquid Ammonia. By Nathan S. Osborne and M. S. Van Dusen. Scientific Paper No. 313; Comparative Tests of Porcelain Laboratory Ware. By C. E. Waters. Technologic Paper No. 105; Determination of Muntz Metal by Selective Corrosion. By H. S. Rawdon. Technologic Paper No. 103.**

**New Geological Survey Reports: Arsenic, Bismuth, Selenium and Tellurium in 1916. By Joseph B. Umpleby; Iron Ore, Pig Iron and Steel in 1916. By E. F. Burchard; Gold, Silver, Copper, Lead and Zinc in Colorado in 1916. By C. W. Henderson; Gold, Silver, Copper, Lead and Zinc in Utah in 1916. By V. C. Heikes; Gold, Silver, Copper, Lead and Zinc in Nevada in 1916. By V. C. Heikes; Sulphur, Pyrite and Sulphuric Acid in 1916. By P. S. Smith; Cement in 1916. By E. F. Burchard; Borax in 1916. By C. G. Yale and H. S. Gale; Magnesite in 1916. By C. G. Yale and H. S. Gale.**

Coal: The resource and its full utilization. By C. G. Gilbert and J. E. Pogue. Smithsonian Institution Bulletin 102, Part 4. U. S. National Museum, Washington, D. C.

The Electrical Properties of Some High Resistance Alloys. By M. A. Hunter and F. M. Sebast. Publication of Electrical Engineering Dept., Rensselear Polytechnic Institute, Troy, N. Y.

Catalog of Rare and Standard Books on exact and applied Science, including the scientific portion of the library of the late Sir James Stirling, and selections from those of George Rennie, and Samuel Roberts. Issued by Henry Sotherant Co., London, Eng. price 2/6.

Bureau of Mines Publications. Bulletin 135, Combustion of Coal and Design of Furnaces, by Henry Kreisinger, C. E. Augistine and F. K. Ovitz. Technical Paper 183. New Views of the Combustion of the Volatile Matter in Coal, by S. H. Katz. Technical Paper 181, Determination of Unsaturated Hydrocarbons in Gasoline, by E. W. Dean and H. H. Hill.

Useful Minerals of the United States, compiled by F. C. Schrader, R. W. Stone, and S. Sanford. Geological Survey Bulletin 624.

Bureau of Standard Publications. Technologic Paper 102. Properties of Portland Cement having a high Magnesia Content, by P. H. Bates. Circular No. 44, Polarimetry, 2nd edition.

**New Bureau of Standards Papers: No. 99, Gas-Mantle Lighting Conditions in Ten Large Cities in the United States. By R. S. McBride, and C. E. Reinicker. No. 95, Durability of Cement Draintile and Concrete in Alkali Soils. By R. J. Wig, G. M. Williams, A. N. Finn, S. H. McGrory, E. C. Bebb, and L. R. Ferguson. No 310, Some Electrical Properties of Silver Sulphite, by George W. Vinal.**

**Bulletin No. 16, Mineral Springs of Canada (in two parts). Part 1. The Radioactivity of some Canadian Mineral Springs. By John Satterly and R. T. Elworthy. Issued by the Canadian Department of Mines, Ottawa, Can.**

## Manufacturers' Catalogs

Driver-Harris Company, Harrison, N. J., have recently issued a bulletin on the subject of pure sheet nickel. Another bulletin on "Nichrome" wire mesh containers for heat treating and acid cleaning is in the course of preparation.

The Bailey Meter Company, 141 Milk St., Boston, Mass., has issued Bulletin No. 41 entitled "How to Save Coal."

The Jeffrey Manufacturing Co., Columbus, Ohio, has issued Catalog 231, describing Jeffrey storage battery locomotives for industrial plants.

The Link-Belt Co., Chicago, Ill., has issued Book No. 358 describing Link-Belt roller chain.

The Merchants National Bank, 28 State St., Boston, Mass., has issued through its Textile Dept. a booklet on the Motor Truck Problem in the textile and allied industries.

The Wheeler Condenser & Engineering Co., Carteret, N. J., has issued a handbook of steam tables especially for condenser work.

The Magnesia Association of America, 702 Bulletin Bldg., Phila. Pa., has issued the first Anniversary Portfolio of the Magnesia Association, under the general title "Let 85% Magnesia Defend Your Steam." The book is a large assemblage of all the educational publicity regarding this insulation which has been appearing during 1917.

Ludlum Electric Furnace Corporation, Woolworth Bldg., New York, has published a catalog of its furnace for making cast steel, cast iron, low-phosphorus pig iron and washed metal from low-grade iron and steel scrap. Four points of excellence in design and operation are discussed. The furnace is made in 5, 10 and 15-ton sizes.

Hungerford & Terry, Inc., Philadelphia, have issued a new catalog on water filters for industrial purposes, describing pressure and gravity filters and water softeners.